THIRD MALAYSIAN POSTGRADUATE CONFERENCE (MPC) 2013

Date: July 4 - 5, 2013

Venue:
Education Malaysia Australia (EMA),
Sydney, New South Wales,
Australia

Organized by

EMA, Sydney
MyPSA, New South Wales

Australia

In conjunction with

Malaysian Summit of Australia (MASA) 2013
(4 - 5 July 2013)

THIRD MALAYSIAN POSTGRADUATE CONFERENCE (MPC2013)

CONFERENCE CHAIRMAN'S PREFACE

The year 2013 represents a significant milestone in the history of Malaysian Postgraduate Student Association of New South Wales (MyPSA-NSW) and Education Ministry of Australia, Sydney (EMAS) with the organisation of the 3rd Malaysian Postgraduate Conference 2013 at the Consulate General of Malaysia, Sydney, New South Wales, Australia on 4-5th of July 2013, concurrent with Malaysian Summit of Australia (MASA) 2013 (previously known as The National Conference and Games (NCG)).

The conference is a forum of intellectual gathering for the Malaysian postgraduate students in Australia. And also this event will gather and to promote the sharing of ideas and knowledge among the students. The conference has helped in bridging researchers working at different institutions in Australia to share their knowledge and helped in motivating young researchers working for their doctoral program. This has also given some clear directions for further research from the deliberations of the conference. Other than that, it also develops self-confidence in the presentation skills and equips the researchers with unexpected future challenges and shortcoming in the academia world.

A number of delegates from different premier academic and research institutions all over Australia have participated and shared their research experiences at the conference. In all 55 contributed and presentations are presented at this yearly event. The range of topics covered from all aspect of study from engineering, medical, humanitarian, art, social sciences, technology, finance and management.

Several people have contributed in different ways for the success of this event. We thank all the authors of the contributed papers, for the cooperation rendered to us in the publication of the conference proceedings. In particular, we would like to place on record, the expert reviewers who have spared their time for reviewing the papers. We also highly appreciate the assistance offered by many volunteers in organising this event and the preparation of the proceedings.

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GENERAL INFORMATION

DATE	:	4 - 5 July 2013
VENUE	:	Education Malaysia Australia (EMA), Sydney, New South Wales, Australia

PAPER PRESENTATION GUIDELINES

1. Paper presentation will be 15 minutes followed by 5 minutes Q&A.
2. Proceedings will be prepared after the conference.

THURSDAY (04 JULY 2013)

07.30am	-	Registration / Breakfast
08.30am	-	Opening remarks
08.40am	-	Keynote address "Malaysian Overseas Postgraduate Candidates' Roles on Malaysia Future Development" by Dr Radzi Jidin from UNSW
09.00am	-	Session 1
11.00am	-	Short break
11.05am	-	Session 2
01.03pm	-	Break / Lunch / Zuhur
01.45pm	-	Session 3
03.45pm	-	Tea Break / Asar
04.00pm	-	Session 4
05.30pm	-	Closing / Maghrib / Dinner

FRIDAY (05 JULY 2013)

08.30am	-	Checkout
09.30am	-	Malaysian Summit of Australia (MASA) 2013
05.30pm	-	Closing

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MALAYSIAN GRADUATES: WHAT AND WHY

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ABSTRACT

Malaysians are bilingual, many are trilingual while a few are multilingual; language is essential for communication and to make connection. What do the local graduates need to equip themselves upon graduation? Communication skills as one of the soft skills, in particular the English language are important which is introduced and incorporated into the curriculum of English language courses in public universities in Malaysia. Why is the number of unemployed Malaysian graduates on the rise? The local graduates have done well academically but language proficiency and communication skills seem to be the competitive factors to secure jobs. This article discusses the needs for Malaysian graduates to be competent users of English language. It also draws some of the challenges in teaching English language to Malaysian learners.

Keywords: Malaysia; English language; globalization; soft skills; communication skills; employment.

INTRODUCTION

In 2010, Malaysian citizens consist of the ethnic groups Bumiputera (67.4%), Chinese (24.6%), Indians (7.3%) and others (0.7%) (Department of Statistics Malaysia, 2010). The Bumiputera ethnic groups include the Malays (63.1%). Apart from the structure of the society, the multiethnic composition of learners is also apparent in classrooms at tertiary level in Malaysia. Therefore, a major problem having heterogeneous background of learners in Malaysian universities is attracting the learners to participate actively in the language classrooms since they are competent in the first language (L1) and mother tongue (MT). Language is essential for communication to take place in our lives and to make connection with other people. *Bahasa Malaysia* (sometimes also known as *Bahasa Melayu* or Malay language) is the national language of Malaysia. Each ethnic group in Malaysia has its own MT including Cantonese, Mandarin and Hokkien (dialects for Chinese), Tamil (dialect for Indians), and several indigenous languages in East Malaysia. Children acquire MT before starting the formal education and will learn *Bahasa Malaysia* and the official second language (L2) of Malaysia, English at schools. Other than the Malay ethnic group, other ethnic groups acquire individual MT, they learn *Bahasa Malaysia* as the L1 and English language as the L2. The advent of the English language in Malaysia was initialized by intense British colonization in the 1800's (Pandian, 2002) and the teaching and learning of English are still entrenched in the current Malaysian education system (Asmah, 1992). The ability to communicate in L1 and L2 make Malaysians to be bilingual; in addition to MT many

are trilingual while a few are multilingual. This paper critically discusses the needs of Malaysians to be competent in English language in order to secure employment and advance in career.

MALAYSIA AND GLOBALISATION

Countries that aspire to achieve a developed country should focus extensively on human capital development. Human capital is an asset to any countries as they are "better equipped to face new global challenges and master technological discoveries" (Rosli et al., 2010, p. 1). In line with the aspiration, human capital development begins at tertiary or higher education playing its "role as dispenser and innovator of knowledge education, contributing towards a nation's growth and development" (Rosli et al., 2010, p. 1). Ultimately, countries which possess high skill level of human capital are able to drive the countries to go global. Globalization is defined as a process where interlinking between countries in the world becomes more intense and the flow of inputs between one country and another will be much easier (Poo & Rahmah, 2012). Rahmah & Poo (2012) accounted that globalization offers opportunities for many kinds of input including labour, thus widening job opportunities for local graduates. Other personal benefits include high income, career prestige, good working conditions, and potential for promotion (Rosli et al., 2010). Simultaneously, Malaysia is focusing on two key areas to improve its competitiveness, which are:

- Competing in global markets to ensure that Malaysia participates successfully in international trade; and
- Competing strongly to attract foreign talent and investment in Malaysia ("Tenth Malaysia Plan 2011 - 2015," 2010, p. 100)

In order to achieve both key areas, the Malaysian tertiary education institutions have a role to train and equip their graduates with the necessary skills to fulfil the needs of employers. In light of the objective, the Ministry of Higher Education, Malaysia then determined seven soft skills for employees to achieve success at workplace (see Figure 1) which tertiary institutions need to inculcate among the local graduates. The ministry directed all public universities to introduce and incorporate the soft skill elements into the curriculum of every undergraduate course. Soft skills are identified as generic skills and require training; in contrast to hard skills which are associated with procedures or tasks that are observable, quantifiable and measurable. Since then, learning in tertiary classrooms has moved away from teacher-centred to student-centred learning.

The move to incorporate soft skill elements into the curriculum was made for two main reasons: first, employers acknowledge that graduates are academically proficient but still lack soft skills; and second, globalization of the work force and job market require the employers to select graduates having the most appropriate skills to their needs (Roselina, 2009). It was also the right move for Malaysia to incorporate soft skills in tertiary education when employers and industry associations emphasize soft skills as the primary factor that hampers employability of many Malaysian graduates ("Tenth Malaysia Plan 2011 - 2015," 2010).

Figure 1. Soft skill elements (*Source* Ministry of Higher Education, 2006*).*

MALAYSIANS AND UNEMPLOYMENT

Malaysian media has consistently reported the unemployment rate of the country. The rate shows a fluctuation between 2007 and 2010. In relation to the study, the concern is on the unemployment rate among the local graduates. The Department of Statistics, Malaysia reported the figures to be 56,322 in 2007, a drop to 47,913 in 2008, a rise to 60,000 in 2009, and the New Straits Times dated 17th March 2013 reported the unemployment rate was 65,500 in 2010. The former Minister of Higher Education, Malaysia, Datuk Seri Mohamed Khaled Nordin, commented in a local newspaper that local graduates had not delivered their soft skills effectively and the four crucial ones included communication, values and etiquette, leadership and critical thinking ("4 punca utama graduan sukar dapat pekerjaan," 2010, March 6). The Star dated 27th July 2013 reported that the two factors that make local graduates still jobless after six months of graduating are lack of language proficiency, particularly in English, and insufficient knowledge and competency in the applied jobs. Every year Malaysian tertiary institutions - both public and private – produce new batches of graduates but the number of them being employed after six months of graduating has been increasing and this is a serious issue to the nation.

The English language appears to maintain its status quo (Rosli et al., 2010). Nevertheless, graduates have not been highly proficient in Malay and English (Azman & Razak, 2007; Gill, 2002); a problem to Malaysia which aspires to become a fully industrialized nation in 2020 (Vision 2020, cf. Mahathir, 1991, as cited in Karchner-Ober, 2012). Ten companies who had been recruiting graduates responded to a survey on the importance of English language to the organizations. 80% of them agreed on the importance of English language in the recruitment of staff (Carol, Khaun, & Singh, 2011). They strongly believed being proficient in the English language would make the employees work effectively in their organization. Similarly, 50 employers in Selangor and Perak affirmed the recruitment of employees depends on their command of English language especially for private sectors (Wei, 2011). Singh and Singh (2008) also stress good English proficiency besides high Information and Communication Technology (ICT) skills, ability to work in a team, and good interpersonal skills as preference by

employers to recruit graduates. The researches show that English is used at the work place, especially in private companies that may own multinational companies and international subsidiaries; whilst *Bahasa Malaysia* is used for correspondence with government agencies. Apart from being competent in the English language and having good academic results, the 50 employers in Selangor and Perak also look for graduates having soft skills elements (see
Figure **1**) (Wei, 2011); but acquiring them has been quite difficult. Based on the source from the Ministry of Higher Education, Malaysia (2006), the soft skills elements measure abilities to communicate in Malay and English languages (communication); think critically, creatively, innovatively and analytically and solve problems (critical thinking and problem solving); work in teams, build relationship, interact and work effectively (lifelong learning and information management); access and manage information (teamwork); develop business proposals and identify business opportunities (entrepreneurial skill); apply ethical principles and professional ethics (moral and professional ethics); and plan, supervise, monitor and lead (leadership). Therefore, tertiary institutions in Malaysia are taking efforts to fulfill the needs of potential employers to ensure the local graduates possess the soft skills for them to secure employment. This section has shown that economy will leverage on the human resource before achieving international trade. Globalization is happening rapidly with the advent of Information technology (IT) and it is a challenge for non-English speaking country like Malaysia to develop its human capital and ensure its learners demonstrate communicative competence in the English language (Nair et al., 2012). Nevertheless, English is the world lingua franca with more than 400,000,000 is either English as second language (ESL) or English as foreign language (EFL) speakers (Kitao, 1996).

MALAYSIANS AND ENGLISH LANGUAGE

Malaysia acknowledges the high importance of English yet graduates from public universities in Malaysia encounter challenges in speaking, writing, reading, and listening in the English language for job-related tasks at the workplace (Carol et al., 2011). The two forms of productive communications skills are written and oral; the receptive skills are reading and listening. Furthermore, the greatest challenge encountered by L2 or foreign language (FL) learners is expressing themselves clearly and fluently (Liu & Jackson, 2008) which is a form of production either in written or spoken. Horwitz (2010) and MacIntyre (1995) believe that language anxiety impedes language production; consequently affects achievement. Questions have been raised on the reasons for Malaysian English language learners to feel anxious towards the language. The first author views learners have no choice but to learn English language for academic purpose and do not foresee the need to use the language outside the classroom. Throughout the primary to the secondary education, the total number of years of learning English language is between 9-11 years. For some learners, English language learning continues to pre-university and undergraduate programs which are addition of 2-4 years. By the end of the formal education, it is anticipated that the Malaysian English language learners have good competency of the language that they are able to interact competently to convey their thoughts clearly with confidence. However, "this proved to be a misguided notion" (Pandian, 2002, p. 39) as the anticipation does not happen generally. Little attention is given on the language competence of Malaysian L2 learners despite the total number of years receiving English language input.

An observation noted by the first author on L2 learners in Malaysian tertiary institutions is those who are competent in the English language use the L2 extensively as their MT or L1. They have built the confidence to use the L2 and feel comfortable communicating in the L2. The confidence is believed to have been developed due to many factors. One of them is the location of the learners' previous schools. The use of English language does not happen at school, in the society nor at home (Gobel, Thang, Sighu, Oon, & Chan, 2013). For such learners, English language is a foreign language (EFL) since the language has been 'practically non-existent' to their lives. As a result, they experience great inferiority complex that could be overwhelmingly daunting. In contrast, learners in urban areas are "in frequent contact with English" (Gobel et al., 2013, p. 55) which directly develops their confidence level and motivation to communicate in the language. The finding suggests that depending on the societal context, English is not a language that is commonly used as an everyday language in areas away from cities either for transactions or conversations. In relation to the locality of learners, Gobel et al. (2013) mentioned that disparity in the urban-rural divide was strongly indicated from the difference in achievement levels between the urban and rural youths on the lower secondary school exit examination. The study shows that English is not spoken all over Malaysia with equal frequency but given the avenues, L2 learners are able to develop confidence in order to communicate in the language.

In Malaysian schools, learning the English language encompasses four language skills – reading, writing, listening and speaking –as well as grammar component. Debate continues about the reasons local graduates are not competent in the L2. With reference to the national examinations, English is a compulsory subject but it is not compulsory to obtain a pass mark in the examinations (Jeannet, 2013). Consequently, not all learners realize the need to practise L2 outside classrooms and they feel adequate to learn the L2 in classrooms only. For example, English language teachers are not able to encourage learners to use the L2 for oral communication outside classroom though Thornton and Houser (2005) claim that if L2 learners get limited opportunity to use English outside the classroom, the engagement in the English language seems impossible for they get opportunities to speak and hear the target language (TL) only in the classroom. Therefore, extending learner opportunities to use the English language is an important strategy to develop the learners' level of competency.

Employees may realize the importance of the English language later in career. To cater to the needs of the public to improve their English proficiency, a few public universities in Malaysia offer English courses. They may take up the English language class again though on own expense for their own job-related tasks. Many government agencies in Malaysia also organize in-house trainings on English courses related to job requirements for their staff development. A Needs Analysis administered to a group of employees found self-confidence and effective oral communications skills in presenting ideas and disseminating information as the qualities that gave them a competitive edge in their jobs (Rohany, 2003). Thus, higher learning institutions provide opportunities for Malaysians to improve their English language competence for career advancement.

CONCLUSION

In conclusion, Malaysia is aiming to become a fully developed nation by the year 2020. Therefore, English language is relatively important for cross cultural communication involving international participation. English, as the world lingua franca, is a means for

social mobility and Malaysian graduates should have an awareness of its importance and develop a positive language attitude to master the language.

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THIN LAYER DRYING OF AGRICULTURAL PRODUCTS: A REVIEW

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ABSTRACT

Drying processes play an important role in preservation of agricultural products. In fact, drying is also one of the complex processes because of the difficulties and deficiencies in mathematical descriptions. The use of thin layer drying mechanisms and equations contribute to better understanding of drying food materials. In this paper, the theory of thin layer drying of food materials which related to agricultural products was explained. Many different equations have been developed to represent the drying characteristics of fruits, vegetables and grains. Then, various modelling equations and approaches for particular products were discussed. The thin layer drying behaviour of agricultural products was identified based on the mathematical models which describe the heat and mass transfer phenomena of the products. The relevance and suitability of mathematical model in describing the drying behaviour of agricultural product was investigated. Some suggestions and recommendations for future research were also included in this paper.

Keywords: Thin layer drying; mathematical modelling; diffusion; drying characteristics

INTRODUCTION

Drying of agricultural products has always been of great importance for the preservation of food. Many food products are dried at least once at some point in their preparation (Madamba, P.S, et al 1996). Drying of fruits and vegetables is a complicated process involving simultaneous, coupled heat and mass transfer, under transient conditions (Diamante, et al 2010). The introduction of dryers in developing countries can reduce crop losses and improve the quality of a dried product significantly when compared to traditional methods. The major objective of drying food products is the reduction of moisture content to a level which allows safe storage over an extended period (Doymaz, et al 2003). Drying consists of a critical step by reducing the water activity of the products being dried. High amount of energy are required due to high latent heat of water. Hot air drying of agricultural products is one of the most popular preservation methods because of its simplicity and low cost (Diamante, et al 2010). To analyse the drying behaviour of a food product, it is essential to study the drying kinetics of the food. Thin layer drying is a common method and widely used for fruits and vegetables to prolong their shelf life (Kadam, et al 2010).

According to (ASAE, 1999), thin layer drying refers to a layer of material exposed fully to an airstream during drying. There is a wide range of thin layer drying

models, thin layer drying models which have found application because of their ease of use. Thin layer drying equations are often empirical to describe drying phenomena in a unified manner regardless of the controlling mechanism (Kadam, et al 2010). Many mathematical models have been used to describe the thin layer drying process of agricultural products. Most workers describe their thin layer drying experiments with suitable mathematical models which can be theoretical, semi-empirical or purely empirical (Madamba, et al 1996). These three categories of models will be discussed further in the next chapter. Thin layer drying equations are used to estimate the drying time of several products and also to generalize drying curves (Meisami, et al 2009). Some of the selected thin layer models of agricultural products are presented in Table 1. A considerable amount of data has been reported in the literature regarding the thin layer drying model of various agricultural products, still continuous effort need to be carried out for further improvement of the drying process. The most important aspect of drying technology is the mathematical modelling of the drying processes and equipment where its purpose is to allow engineers to choose the most suitable operating condition for certain product. Therefore, the objective of this project was to study and investigate the thin layer drying characteristics of particular products and the mathematical models that have been used to describe the thin layer drying process.

Table 1. List of selected thin layer drying models of various agricultural products.

No.	Agricultural products	Authors/year	Best Thin layer drying model
1	Macadamia in-shell nuts and kernel	Palipane, et al (1994)	Two-term
2	White onion slices	Rapusas, et al (1995)	Single term exponential
3	Garlic slices	Madamba, et al (1996)	Page and two compartment
4	Black tea	Panchariya, et al (2001)	Lewis
5	Corn	Doymaz, et al (2003)	Page
6	Red pepper	Akpinar, et al (2003)	Diffusion model
7	Eggplant slices	Ertekin, et al (2004)	Midilli et al model
8	Soybean	Rafiee, et al (2009)	Midilli et al model
9	Cocoa	Hii, et al (2009)	Combination of Two-term and Page
10	Grape seed	Robert, et al (2008)	Lewis model
11	Apple slices	Meisami, et al (2009)	Midilli et al model
12	Mint leaves	Kadam, et al (2010)	Two-term
13	Kiwi and apricot	Diamante, et al (2010)	Empirical model
14	Litchi and peeled longan	Janjai, et al (2011)	Page
15	Rapeseed	Duc, et al (2011)	Page
16	Roselle	Suherman, et al (2012)	Newton/Lewis

THIN LAYER DRYING

Thin Layer Drying Mechanisms

Referring to (ASAE, 1999), thin layer drying can be described as a drying of one layer sample particles or slices. Due to its thin layer characteristics, we assume that the temperature distribution is uniform, thus making thin layer drying suitable for lumped parameter models. The main mechanisms of drying are surface diffusion on the pore surfaces, liquid or vapour diffusion due to moisture concentration differences and capillary action in granular and porous foods due to surface forces (Erbay, et al 2010). Generally, hygroscopic products dry in constant rate and subsequent falling rate periods and drying stops when equilibrium is established (Erbay, et al 2010). During the constant rate period of drying, the physical form of the product and external conditions such as temperature, drying air velocity, direction of air flow and relative humidity have a great influence on the surface of the product being dried so called surface diffusion. When the surface film of the solids or particles appears to be dried and the moisture content has been reduced to its critical moisture content, M_c then the first falling rate period begins. Unlike the constant rate periods, the falling rate period is controlled by liquid diffusion as a result of moisture concentration differences and the internal conditions of the product. The internal conditions such as moisture content, the temperature and the structure of the product play an important role in the falling rate periods. This phenomena will then be replaced by the second falling rate periods of drying namely vapour diffusion due to moisture concentration difference and also internal conditions of the products. It has been accepted that the drying phenomenon of biological products during falling rate period is controlled by the mechanism of liquid and/or vapour diffusion (Panchariya, et al 2001). A complete drying profile consists of two drying stages; a constant rate period and falling rate period. However, not all grains follow this pattern (Duc, et al 2011). In most cases, the falling rate period is reported as governed by diffusion mechanism in thin layer drying of agricultural products. Figure 1 shows the schematic diagram of thin layer dryer system that has been used for drying purposes.

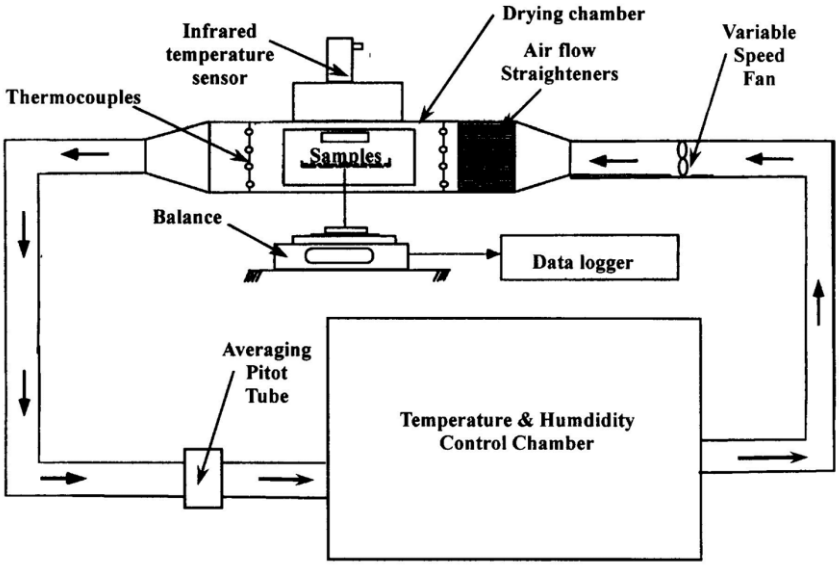

Figure 1. Schematic diagram of thin layer dryer.

Mathematical Models of Thin Layer Drying

Thin layer drying equations are important tools in mathematical modelling of drying (Erbay, et al 2011). Thin layer drying models that describe the drying phenomenon of biological materials mainly fall into three categories, theoretical, semi-theoretical and empirical (Panchariya, et al 2001). Theoretical models explain the drying behaviours of the product clearly and can be used for all process conditions, but may include assumption about moisture mechanisms which may cause considerable error. The Fick's second law equation is a theoretical model that has been used widely for thin layer dying process. Semi-theoretical models are generally derived from Fick's second law and modifications of its simplified forms. The theoretical model takes into account only internal resistance to moisture transfer while the semi-theoretical and empirical models consider external resistance to moisture transfer resistance between product and air (Panchariya, et al 2001). A theoretical equation gives a better understanding of the transport processes but an empirical equation gives a better fit to the experimental data without any understanding of the transport processes involved (Janjai, et al 2011). The empirical models have similar characteristics with semi-theoretical models but they are strongly depending on the experimental conditions and mostly give limited information on the drying process. The semi-theoretical or semi-empirical gives some understanding of the transport processes (Janjai, et al 2011). Simpler models should be a wiser option considering the complexity of the process and the lack of required data (such as phenomenological and coupling coefficients) (Madamba, et al 1996).

Empirical Models

The empirical model is basically a direct relationship between the average moisture content and the drying time. The only drawback of empirical model is that it neglects the fundamentals of the drying process hence their parameters have no physical meaning.

***a. Thompson model*:**

$$t = a\,ln(MR) + b\,[ln(MR)] \tag{1}$$

***b. Wang and Singh model*:**

$$MR = 1 + b^{*}t + a^{*}t^{2} \tag{2}$$

***c. Diamante et al (2010) model*:**

$$ln(-\ln MR) = a + b(ln\,t) + c(ln\,t)^{2} \tag{3}$$

Theoretical Models

Unlike empirical model, theoretical model considers only internal resistance to moisture transfer. In thin layer drying of agricultural products, analysis of the dehydration process that takes place in the falling rate drying period is calculated by using a diffusion model based on Fick's second law (Duc, et al 2011). Assuming that the resistance to moisture flow is uniformly distributed throughout the interior of the

homogeneous isotropic material, the diffusion coefficient, D is independent of the local moisture content and if the volume shrinkage is negligible, then Fick's second law can be derived as follows:

$$\frac{\partial M}{\partial t} = D\nabla^2 M \tag{4}$$

This equation is also called lumped parameter models. The model does not consider the temperature gradient in the product but assumes a uniform temperature distribution equal to the drying air temperature. The assumptions concerning uniform temperature distribution and temperature equivalent of the ambient air and product may cause errors (Erbay, et al 2011). It is possible to determine analytical solution of diffusion equation for some simple geometry under certain assumptions:

i. The particle is homogenous and isotropic
ii. The material characteristics are constant and the shrinkage is neglected
iii. The pressure variations are neglected
iv. Evaporation occurs only at the surface
v. Mass transfer is symmetrical and uniform during process
vi. When drying begins, the surface moisture content instantaneously reaches the equilibrium moisture content
vii. Temperature distribution is uniform and equals to the ambient drying air temperature
viii. Heat transfer is represented by conduction within the product and by convection outside of the product
ix. Effective moisture diffusivity is constant with moisture content during drying

These are some equations for different particles or product according to its geometry:

$$MR = \frac{8}{\pi^2}\left[exp\left(-\frac{\pi^2 D_{eff}\, t}{4L^2}\right) + \frac{1}{9}exp\left(-9\frac{\pi^2 D_{eff}\, t}{4L^2}\right) + \frac{1}{25}exp\left(-25\frac{\pi^2 D_{eff}\, t}{4L^2}\right) + \frac{1}{49}exp\left(-49\frac{\pi^2 D_{eff}\, t}{4L^2}\right) + \cdots\right],$$

for infinite slab (5)

$$MR = \frac{6}{\pi^2}\left[exp\left(-\frac{\pi^2 D_{eff}\, t}{L^2}\right) + \frac{1}{4}exp\left(-4\frac{\pi^2 D_{eff}\, t}{L^2}\right) + \frac{1}{9}exp\left(-9\frac{\pi^2 D_{eff}\, t}{L^2}\right) + \frac{1}{16}exp\left(-16\frac{\pi^2 D_{eff}\, t}{L^2}\right) + \cdots\right],$$ ***for spherical bodies*** (6)

$$MR = 0.692exp\left(-5.78\frac{D_{eff}\, t}{L^2}\right) + 0.131exp\left(-30.5\frac{D_{eff}\, t}{L^2}\right) + 0.0534exp\left(-74.9\frac{D_{eff}\, t}{L^2}\right) + 0.029exp\left(-139.1\frac{D_{eff}\, t}{L^2}\right) + .., \textbf{\textit{for infinite cylinder}} \tag{7}$$

where *L* the characteristic length (m). Moisture ratio, *MR* can be determined according to the external conditions. If the relative humidity of the drying air is constant during the drying process, then the moisture equilibrium is constant too (Erbay, et al 2011). However, if the relative humidity of the drying air continuously fluctuates, then the equilibrium moisture content also varies. The moisture ratio, *MR* is defined by Eq. (10):

$$MR = \frac{(M - M_e)}{(M_i - M_e)} \tag{8}$$

where *M* is the moisture content at time *t*, M_e is the equilibrium moisture content, M_i is the initial moisture content and all are measured on a dry basis. It has been accepted that most agricultural products dry without a constant rate period, thus M_i is equal to M_c which is defined as the critical moisture content at the end of the constant rate period of drying. By using Fick's second law with Arrhenius-type temperature-dependent diffusivity, the drying characteristics of many food products such as rice, hazelnut and rapeseed have been successfully predicted (Panchariya, et al 2001).

Semi-theoretical or Semi- Empirical Models

The semi-theoretical models are generally derived by simplifying general series solutions of Fick's second law or modification of simplified models and are valid within the experimental temperature, relative humidity, air velocity and moisture content range (Panchariya, et al 2001 and Erbay, et al 2011). Semi-theoretical models can also be derived from Newton's law cooling. Here are some of the semi-theoretical models that are widely used in describing the thin layer drying characteristics of agricultural products.

a. ***Lewis/Newton model*:**

$$MR = \frac{M-M_e}{M_o- M_e}=exp(-k_o t) \quad (9)$$

b. Page/(modified Lewis) Model

$$MR = \frac{(M_t-M_e)}{(M_i-M_e)} = exp(-kt^n) \quad (10)$$

c. Single Term (Henderson and Pabis) Model

$$MR = \frac{(M_t-M_e)}{(M_i-M_e)} = A_o\ exp(-k_o t) \quad (11)$$

d. ***Two term/ two compartment model***

$$MR = \frac{(M_t-M_e)}{(M_i-M_e)} = A_o\ exp(-k_o t) + A_1\ exp(-k_1 t) \quad (12)$$

e. Two term exponential model (Form of two term model)

$$MR = \frac{(M_t-M_e)}{(M_i-M_e)} = A_o\ exp(-k_o t) + (1- A_o)\ exp(-k_1 a t) \quad (13)$$

f. ***Logarithmic(Asymptotic) model***

$$MR = \frac{(M_t-M_e)}{(M_i-M_e)} = A_o\ exp(-k_o t) + c \quad (14)$$

g. ***Midilli model***

$$MR = \frac{(M_t-M_e)}{(M_i-M_e)} = A_o\ exp(-k_o t) + bt \quad (15)$$

h. ***New transient diffusion model***

The new transient diffusion model is derived based on the moisture ratio between two layers of a product. By considering the value of μ (moisture ratio), k_1 and k_2 during drying period, this model is expected to give better respond when changing drying conditions.

$$\frac{\partial M}{\partial t} = \frac{k_1 \mu}{1+\mu}\frac{\partial M_1}{\partial t} - \frac{k_2}{1+\mu}\frac{\partial M_2}{\partial t} \quad (16)$$

where $A_{o,}\ A_{1,}\ b, n,\ k_1, k_2, \mu$ are the constants to be found and determined from experimental data.

THIN LAYER DRYING CHARACTERISTICS OF PARTICULAR PRODUCTS

Rice

(Yodollahinia, et al 2008) had reported that **two terms model** could predict moisture changes rice paddy with greater accuracy than other models. The experiment on the drying kinetics of rice paddy (Fajr cv) were conducted at five drying air temperatures ranging from 30 to 70°C, in four air velocities ranging from 0.25 to 1.0 ms^{-1} and three replication on each condition. The two terms model was found to be better describe at all drying air temperatures with average R^2 value of 0.9985. It showed strong dependence of drying rate with temperature as drying rate increases when air temperature increases. However, air velocity had a very little effect on the duration of period of drying rice paddy (Yodollahinia, et al 2008). Another research finding on thin layer drying of rough rice was reported by Hacihafizoglu et al, (2008). It was stated that long grain rough rice was used in this study. The same parameter of drying air temperatures (40, 45, 50, 55 and 60°C) and air velocities (1.5 ad 3.0 ms^{-1}) specified by Cihan (1991) was used in the experiments. Twelve models were considered in this study where **Midilli et al model** gave better average value of R-squared (0.9999) and SEE (0.00355) as compared to other models. Since Midilli et al model is the modification of the diffusion equation, the situation is consistent with the fact that the transport mechanism is the diffusion dominant due to low porosity of rough rice. Therefore, this model was acceptable for the purpose of simulation of drying rough rice (Hacihafizoglu, et al 2008).

Garlic Slices

By comparing four mathematical models, the **Page and the two compartment models** gave better predictions than the single term and Thompson's model. From 27 runs of experiment, an acceptable R^2 value of greater than 0.9 was obtained for all models. However, the MSE_s values showed that the two compartment model had superior fit to the data compared to the Page and the lumped exponential equation. Another criterion that was taken into account is the P-values or the mean relative deviation modulus (P). Both page and two compartment models gave the least P-value of below 10% compared to other models. From the statistical analysis, it was found that temperature and slice thickness significantly affected the drying rate while relative humidity and airflow rate were insignificant factors during drying. A high initial drying rate (with higher rates at higher temperatures) was observed followed by gradual decrease as the material

approached the dried state and most of the drying of garlic slices took place in the falling rate period (Madamba, et al 1996).

Eggplant Slices

The **Midilli et al model** was found to be a suitable model for describing the drying curves of eggplant slices. In this experiment, pre-treatment was applied in order to decrease drying time. It also reduces the resistance to moisture transport and thereby increasing the drying rate. A thinner slice also contributes to a shorter drying time. When the slice thickness increases to 1.27 and 2.54 cm, drying time had increased by about 104% and 294% according to a slice thickness of 0.635 cm. Therefore, it can be concluded that the mean drying rate was higher at lower slice thicknesses. Thinly sliced products dried faster due to the reduced distance the moisture travels and also increased surface area exposed for a given volume of the product. The effects of drying air temperature and velocity was determined at the fixed slice thickness of 0.635 cm. It was found that the drying time decreased with increasing drying air temperature and velocity. There was no constant rate period in the drying of eggplant slice, thus the most effectual force governing the moisture movement in the eggplant was diffusion. It was reported that Midilli et al model gave the lowest values of RMSE and this value was changed between 0.0005 and 0.0170 compared to other models. Thus, Midilli et al model could be used to explain moisture transfer in eggplant slices (Ertekin, et al 2004). However, there was no data of analysis for different models provided in the literature.

Mint Leaves

According to (Kadam, et al 2010), **two-term model** was found to be satisfactorily described the drying behaviour of mint leaves. The average thickness and moisture content of fresh mint leaves were 0.26 mm and 470.78% (db). Although R^2 values for all models were found to be greater than 0.80 at all temperatures, the two term model was superior with the highest R^2 value and also the lowest values of χ^2, MBE and RMSE at each temperature. The two term model with the highest R^2 value of 0.998 represented thin layer drying behaviour of mint leaves in tunnel dryer. It was observed that drying of mint leaves occurred primarily in falling rate period and no constant rate period was found at all drying temperatures. Moisture depletion per hour was higher at initial stages and then started to decrease with drying time. The falling rate period indicated that initial mass transfer occurred by diffusion. It was found that drying time varied from 240 to 390 minutes to dry a 300 g of mint leaves at temperatures from 45 to 65°C (Kadam, et al 2011).

Corn

The **Page model** showed a better fit for all conditions (55, 65 and 75°C) than a simple exponential model according to Doymaz (2003). For the untreated and treated corn kernels, the Page model gave R-squared value of 0.999 and 0.997 respectively. Ripe corn, *Zea mays indentata* grown in the region of Adapazari, Turkey was used during the experiments. The shorter drying times and best quality dried product were obtained with corn kernels dipped in a solution of ethyl oleate. Ethyl oleate solution removes the wax layer on the surface of corn kernels and allows the water in corn to diffuse from the surface. Hence, using the ethyl oleate solution, the drying time of corn had decreased

during drying (Doymaz, et al 2003). However, it is preferable to compare the experimental data with other mathematical models in order to better describe the drying behaviour of corn. Nevertheless, this paper had shown a substantial difference between the untreated and treated corn in term of drying rate as the drying time decreased by 35%, 25% and 16.7% for treated corn kernels. Hacihafizoglu, (2009) had also proved that the drying behaviour of corn can be modelled reasonably by **liquid diffusion model**. The drying experiments were carried out at temperatures range of 40-70°C with three different geometries (slab, sphere and cylinder) were taken into consideration to represent corn grains. Hybrid-type corn was used in the experiments and the drying process was conducted immediately after harvest without applying any pre-treatment. It was found that the solution based on sphere geometry gave better agreement with the experimental drying behaviour compared with other geometries. The sphere geometry produced the highest value of R-square on each drying temperature and had the lowest error and deviation. The sphere geometry gave the highest diffusion coefficient as it has the lowest surface area. Unlike slab geometry which has the highest surface area, the diffusion coefficient gets the smallest values. There was no constant rate period occurred in the corn drying and all the drying process took place in the falling rate period. It can be concluded that during the falling rate period, moisture is transferred from the inner parts to the surface of the corn grains thus slowed down the drying rate. Therefore, Hacihafizoglu et al (2009) suggested that drying should be ceased periodically in order to permit the movement of moisture from the inner parts to the surface of the corn grains or so called intermittent drying. This paper had successfully described and explained that the theoretical predictions based on the sphere geometry was in better agreement with the experimental results.

Roselle

The **Newton model** was the most adequate model for describing the thin layer drying kinetics of the Roselle followed by Henderson and Pabis, two terms model and two terms exponential. The Newton model had a maximum value of R^2 (0.9963) at 60°C and had lowest values of x^2 and RMSE as well. The drying constant was found to vary linearly with temperature. It can be concluded that drying air temperature had an important effect on the drying rate and the total drying process was found to occur in the falling rate period only. Hence, the drying behaviour of the Roselle was diffusion governed (Suherman Fajar, et al 2012). However, there was no report on the number of replications being run in the experiments. Moreover, assuming Roselle samples with slab geometry might not be an appropriate way to determine its effective diffusivity. Therefore, by considering different geometries further research need to be done in order to better describe the drying behaviour of Roselle.

Macadamia in-shell nut and kernels

The **two-term exponential model** was accurately predicted the drying behaviour of macadamia in-shell nuts and kernels as compared to single-term exponential model (Palipane, et al 1994). It was observed that when kernels were dried by directly exposing them to drying air the kernel surface became glossy in appearance and oily than when they were dried in shell. This could be happen when the kernels are directly exposed to the drying air a higher moisture gradient is created between the inner tissue and the surface layers of the kernel. Furthermore, the concentration of oil in the outer

layers of the kernel may cause a resistance to moisture transfer during the final stages of drying. The result indicated that the model fits the experimental data and that the initial moisture content has not affected the drying behaviour of the macadamia kernels. At low moistures, the removal of moisture from the kernels is faster when in-shell nuts are dried than when extracted kernels are dried (Palipane, et al 1994). It was observed that the time taken to dry in-shell nuts from 9.1% to 4% (4% refers to a kernel moisture content of 1.03%) is 44 hr whereas the time taken to dry kernels from 3% to even 1.5% is 48 hr. In conclusion, it can be summarized that it is advantageous to dry nuts in shell rather than applying the two stage approach of drying in-shell nuts followed by drying of the kernels unless there is a greater advantage in terms of kernel recovery when nuts are cracked at a higher moisture level (Palipane, et al 1993).

EVALUATION OF MATHEMATICAL MODELS OF DIFFERENT PRODUCTS

Due to the complexity of transport mechanisms, semi-empirical models are often used to describe the thin layer drying behaviours of food materials. Of all semi-empirical models, **two compartments** or two terms model has been used widely in determining the thin layer drying characteristics of product. The thin layer drying characteristics of garlic slices, macadamia in-shell nuts and kernels, mint leaves and rough rice were satisfactorily described by the two compartment model. Palipane, et al (1994) proved that the two term model gave better predictions of the experimental values especially over long drying periods. Palipane, et al (1994) also indicated that the best correlation between moisture content and drying time covering all the drying runs was obtained with the two term model. The two compartment model was chosen as an adequate model for certain products due to its lesser number of parameters and its physical significance. Obviously, product consists of several compartments is better described by more than a single term due to internal drying resistances of each compartment. Yodollahinia, et al (2008) used two-term model to explain the thin layer drying behaviour of rough rice with three compartments, the hull, bran and endosperm. Semi-theoretical models are generally derived by simplifying general series solutions of Fick's second law or modification of simplified model. Based on the Crank solutions, diffusivity of a particular product is determined by assuming the geometry of the product itself. As most of the agricultural products are not uniform, it is difficult for researchers to specify the shape or geometry of the product. The two compartment model is found to be an accurate model when dealing with long drying period but still it does not respond well to changing conditions such as air temperature. Therefore, a **new transient diffusion model** which is shown in Eq. (16) is introduced to describe drying behaviour of agricultural product. Due to moisture ratio differences between two layers during drying, it is expected to give better respond to experimental data and predict the drying behaviour of a product. Further experimental and research works need to be carried out in order to verify its expected outcome.

EFFECTS OF DRYING AND PRODUCT CONDITIONS ON DRYING RATE

Many variables involve in thin layer drying of agricultural products such as product temperature which is assumed to be equal to the drying air temperature, initial product moisture content, air velocity, relative humidity and product thickness. Based on literature, drying air temperature and product thickness are proved to be the major factors which affect the heat and moisture transfer rates whereas air velocity has a little

effect on drying rate. Rapusas, et al (1995) agreed that temperature and the slice thickness were significantly affected the drying rate of white onion slices. Ertekin, et al (2004) found that the thinner slices of eggplant, the shorter the drying time. By referring to Figure 2 and 3, Madamba, et al (1996) also showed that both temperature and slice thickness had a significant effect on the drying rate while relative humidity and air flow rate had a very little effect. However, relative humidity of the drying air has a vital impact on the final moisture content of the product as it controls the rate of water vapour transport from the product surface to the air. Duc, et al (2011) proved that the moisture ratio had a steeper decreasing slope with increasing air temperature as well as decreasing relative humidity. Obviously, increase in temperature of drying air reduces the time required to reach any given level of moisture ratio since the heat transfer increases whereas decrease in the relative humidity of drying air reduces the time required to reach any given level of moisture ratio since the mass transfer increase. In other word, an increase in relative humidity decreases the drying rate. Researchers generally agree that pre-treatment of product before drying plays an important aspect in reducing the drying time. As shown in Figure 4, Doymaz, et al (2003) showed that there is a significant difference between the untreated and treated corn in term of drying rate as the drying time decreased by 35%, 25% and 16.7% for treated corn kernels. Doymaz, et al (2011) also compared various pre-treatments with the blanched samples had shorter drying time compared to other methods and untreated samples.

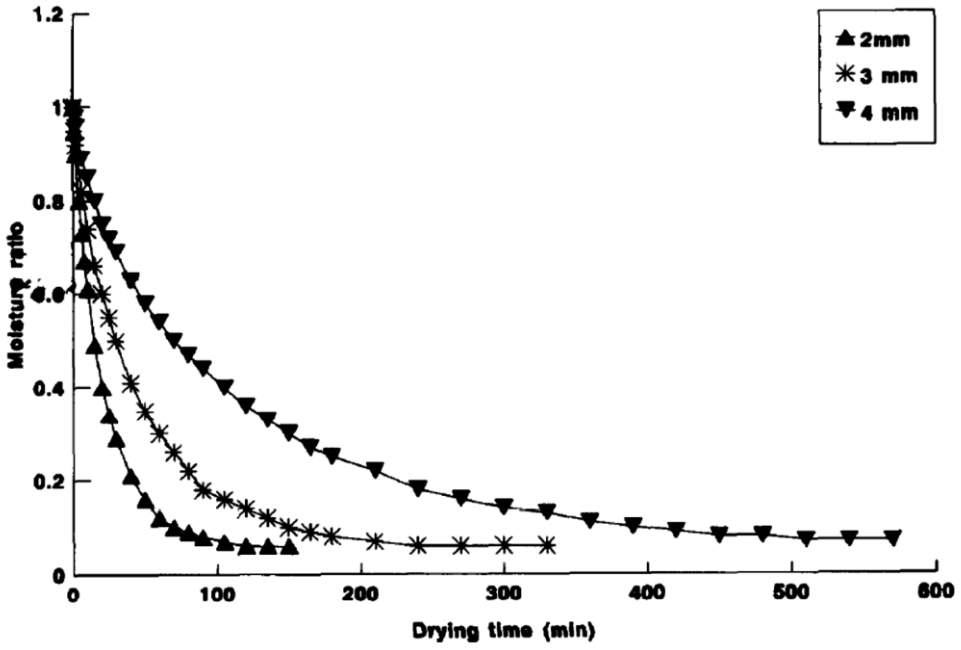

Figure 2. The influence of thickness on moisture ratio at different temperatures of garlic slices (Madamba, et al 1996).

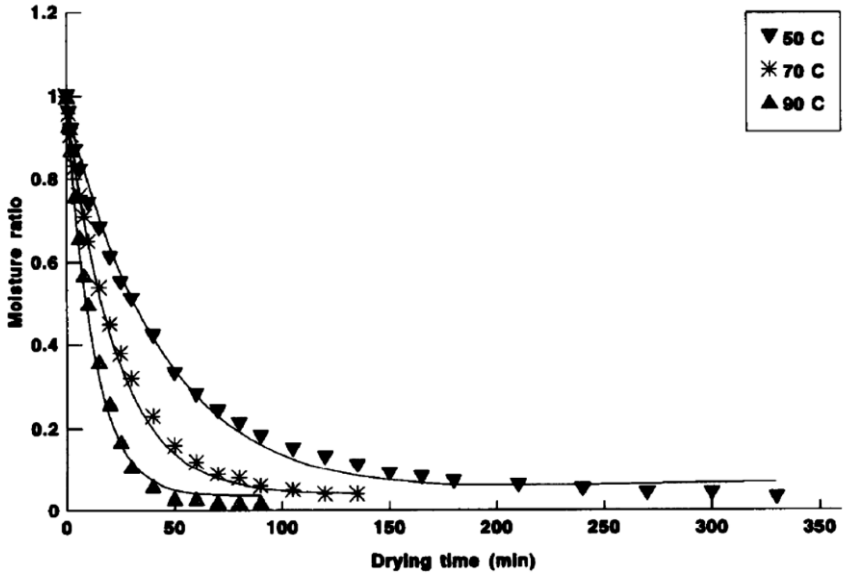

Figure 3. The influence of drying air temperatures on moisture ratio of garlic slices (Madamba, et al 1996).

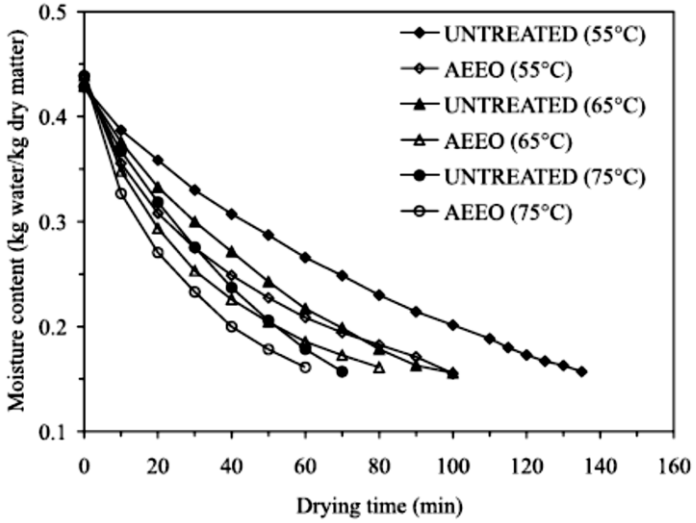

Figure 4. Effect of ethyl oleate (AEEO) dipping on the drying curves at different temperatures of corn kernels (Doymaz, I., et al 2003).

CONCLUSION AND RECOMMENDATIONS

In this paper, mathematical models for various products were reviewed and replicated studies on the same product and method was discussed. The effects of drying and product conditions were studied and explained in order to describe the drying characteristics of products. The main conclusions of this study were listed below:

a) Drying kinetics of most agricultural products showed a falling rate period which is governed by liquid diffusion mechanism;
b) Drying air temperature and slice thickness were significant factors in drying most of agricultural products compared to air velocity;

c) Besides of increasing the drying rate, pre-treatments play a key role in optimization, addressing mainly keeping colour and texture of dried products;
d) The semi-theoretical models were the most reliable models as they have theoretical basis and better fit the experimental data;
e) The empirical model was not an appropriate model when describing the drying behaviour of agricultural products because no theoretical basis that could be explained for the good curve fitting ability of the equation;
f) Although new mathematical model was introduced and used to describe the drying behaviour of agricultural product, further research needs to be done before confirming its validity to other fruits.
g) Although there have been lots of studies conducted on agricultural products such as fruits, vegetables and grains, there is still insufficient data in drying of a product with different variety;

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Nomenclature

a, b, c, n	empirical constants in drying models
db	dry basis
D_{eff}	effective moisture diffusivity m^2/s^1
K	drying constant
L	thickness of slice
M_e	equilibrium moisture content
M_o	initial moisture content
MR	dimensionless moisture ratio
R^2	coefficient of determination
$RMSE$	root mean square error
X^2	reduced Chi-Squared

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TENSILE BEHAVIOURS OF ACTIVATED CARBON COCONUT SHELL FILLED EPOXY COMPOSITES

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ABSTRACT

This research is to develop a carbon composite prepared from carbon coconut shell reinforced with epoxy resin. Carbon coconut shell were selected from three types of coconut shell specifically namely as carbon *Komeng* coconut shell (CKCS), carbon young coconut shell (CYCS) and carbon ripe coconut shell (CRCS). The samples were prepared using epoxy resin reinforced with four different weight percentages of three types of carbon coconut shells starting with 0wt.%, 5wt.%, 10wt.% and 15wt.%. The Tensile behaviour of all samples was investigated to characterize the quality of the samples. The morphological study of reinforced samples was also conducted in this research by using SEM machine. The chemical composition and surface chemistry of these coconut shells were also determined to evaluate its importance in determining the end-use properties of composites.

***Keywords*:** Coconut; Epoxy Resin; Reinforced; Tensile.

INTRODUCTION

Coconut shell is non-food part of coconut which is hard lignocellulosic agro waste. It was reported that contain of coconut shell ratio to overall coconut fruit itself in percentage, it has only 15–20% (Andrzej et al., 2010). Asia region, Malaysia, Indonesia, Thailand, and Sri Lanka are major producing country of natural filler coconut shell. In 2011, nearly 100,000 hectares of land have been utilised for coconut plantation that yields over 577,000MT of coconuts annually thus putting Malaysia as the 10th largest coconut producing country in the world (UNCTAD 2012). Agro waste product such as coconut shell is an annually increase every years and is available in abundant volume throughout the world. Agro waste raw materials could be a potential alternative replacing wood for making composite material particularly for automobile, packaging and construction applications. In fact, several automobile makers in Europe are using natural fibre composites in their car like a Mercedes Benz sedan (Monteiro et al., 2010). Previous research already discovered that lignocellulosic raw material such as coir fibre has been used for making composites reinforced with polymeric resin such as polyester (Santafé Júnior et al., 2010). Another part of coconut such as coconut shell reinforced Polypropylene also reported (Bledzki et al., 2010). Previous report also indicated that fibre length of coconut fibre reinforced epoxy resin varied the mechanical properties of composites (Sandhyarani at al., 2011). Apart from composite materials, the particleboards from agro by-product could be another potential alternative (Awang et

al., 2012). Nowadays, special concern has been manifested towards ‘‘green composites”. Some of the effort has been based on the use of new waste sources, with the aim to obtain biologically active compounds which can be applied in different fields and applications (Awang et al., 2012). The waste of coconut fruit shell or crust are totally not being used and normally discarded as garbage (Monteiro et al., 2010). Currently, defective coconut such as *Komeng* coconuts are considered as having no economic value and not utilise for composite in engineering application (Andrzej et al., 2010). In this paper, three types of coconuts have been used such as CKCS, CYCS and CRCS for investigating the tensile behaviour. Activated Carbon (AC) was produced and reinforced with all these carbon to fabricated composite.

MATERIALS AND METHODS

All the coconuts shells firstly were weighed using digital weighing machine; then they were cleaned with fresh water and lastly dried at room temperature. After that all the coconuts shell were burnt in the oven with temperature ~80^{o}C until 5 minutes so that it become coal or powdered ash. Epoxy resin and hardener were used type 3554A with the density of 1.15 g/cm^{3}. The dumbbell-shape samples were prepared according to the standard ASTM D2099 for tensile test. Tensile tests were carried out using an Instron machine at Mechanical Engineering Department UPM Serdang Malaysia. The surfaces of the specimens are examined directly by scanning electron microscope model Hitachi accompanied with XRF to determine the chemical composition of the specimens.

RESULTS AND DISCUSSION

Figure 1 shows the tensile stress for all samples CKCS, CYCS and CRCS with different weight percentage (wt.%). It was shown that tensile stress trend for CKCS coconut carbon composite slightly increased start from 5 wt.% to 15 wt.%. Compared with CYCS and CRCS strengthen coconut carbon composite decreased dramatically even though CRCS a little bit increased at 10 wt.% of carbon content. The increasing of carbon content internally occurred might make the strength of CKCS sample higher than CYCS and CRCS samples. It can be seen that tensile stress of the composites increase with an increase of the filler content. The composites demonstrate somewhat linear behaviour. Mechanical properties of the coconut carbon shell composites depend on several factors such as the stress–strain behaviours of carbon and matrix phases, the phase volume fractions, the carbon concentration, the distribution and orientation of the carbon or fillers relative to one another. The increase of the filler content, results in the increase in tensile stress. This is due to the fact that coconut carbon filler particles strengthen the interface of resin matrix and filler materials. The maximum tensile strength of 10% filler composite was higher (18.34 MPa) belong CYCS at Figure 1(a) compared to other two combinations. While the trend for CKCS shows slightly increase at 15% with 15.55MPa starting from 5% carbon content at Figure 1(b). At lower concentration of the filler material, specimen CYCS and CRCS demonstrated slightly linear behaviour prior to sharp failure or fracture. This means that specimen deformed plastically immediate after elastic deformation.

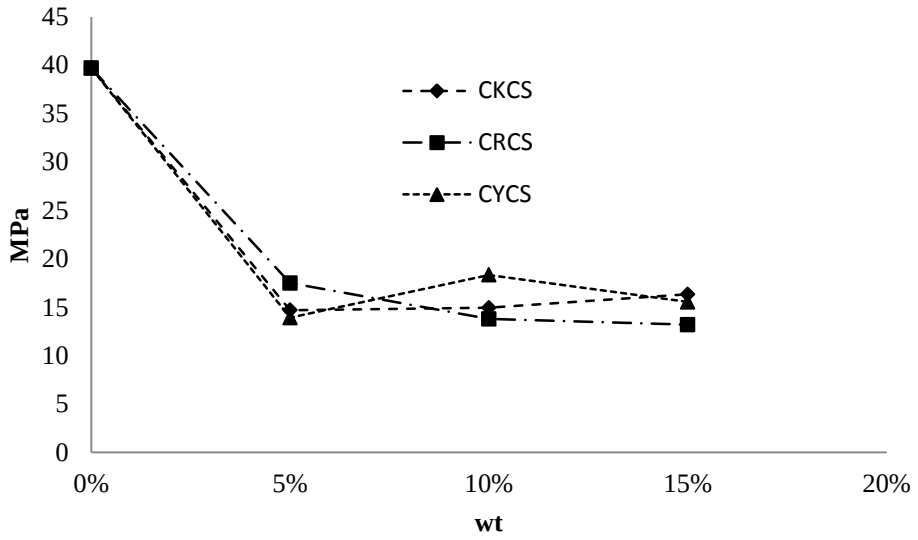

Figure 1. Tensile stress CKCS, CRCS CYCS composites.

Figure 2 shows the tensile strain for all samples CKCS, CYCS and CRCS with different weight percentage (wt.%). The graph shows tensile strain varied with difference weight percentage of AC contents. Starting with 5wt%, tensile strain at break for CKCS sample shows maximum value with 1.47% compared with CYCS and CRCS samples. Tensile strain drastically decreased from 1.50% to 0.80% for CKCS samples until met together at 15wt% with strain value is ranging from 0.60% to 0.70%.

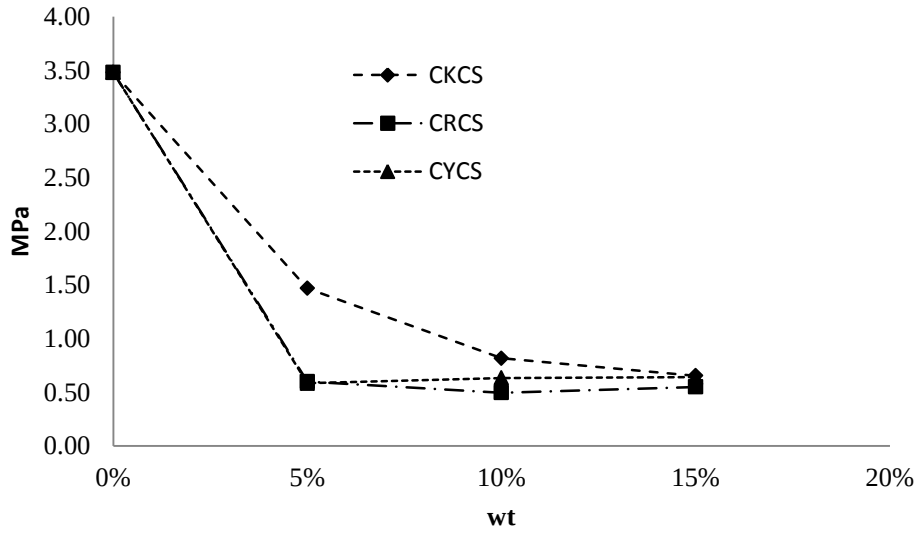

Figure 2. Tensile strain CKCS, CRCS and CYCS composites.

Figure 3 shows the tensile modulus for all samples. From the graph, CKCS composite show spontaneously increased their modulus when compare with CRCS and CYCS even though CYCS achieved the maximum tensile modulus 3161MPa.

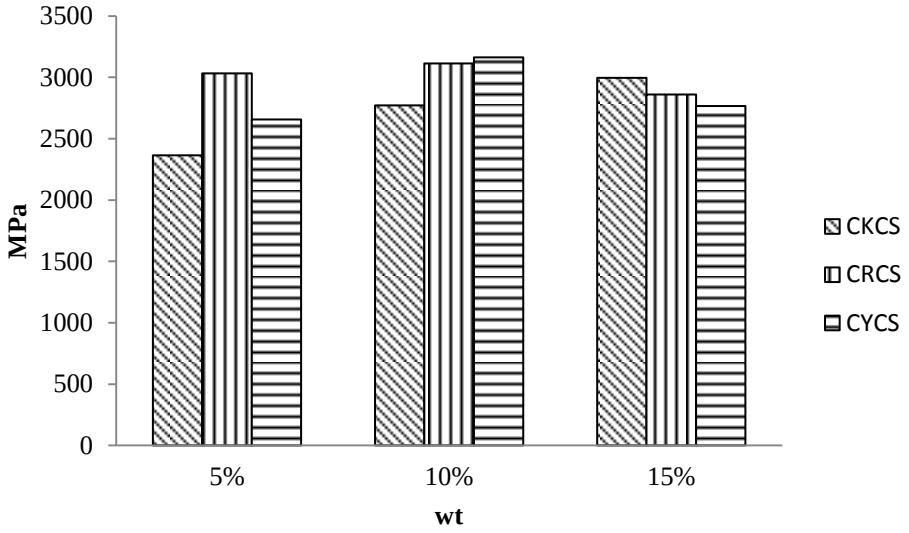

Figure 3. Tensile modulus CKCS, CRCS and CYCS composites.

Chemical compositions with microphotographs of the selected for coconut shell are shown in Figures 4, 5 and 6 show that the inspection spectra of coconut shell internal surface elements acquired for CKCS, CYCS and CRCS respectively. The samples exhibit spectra containing mainly carbon, chlorine, kalium, oxygen and small amount of silicon, potassium, sulphur, and magnesium. The higher proportion of carbon in coconut shell can be attributed to the presence of hydrocarbon rich waxy coating on the cuticle of endocarp of coconut shell when present on the surface as activated carbon applications (Awang et al., 2012). The silicon contains in samples may have the influence on the properties of activated carbon reinforced composites. The oxygen content for CKCS also contributed for the toughness of the composite as usual if compared with CYCS and CRCS samples. This can be determined with the CKCS sample where the tensile behaviour is drastically increase when contents of AC are proportional increased. All these two composition made the composites more strength compared to others natural composite materials (Andrzej et al., 2010).

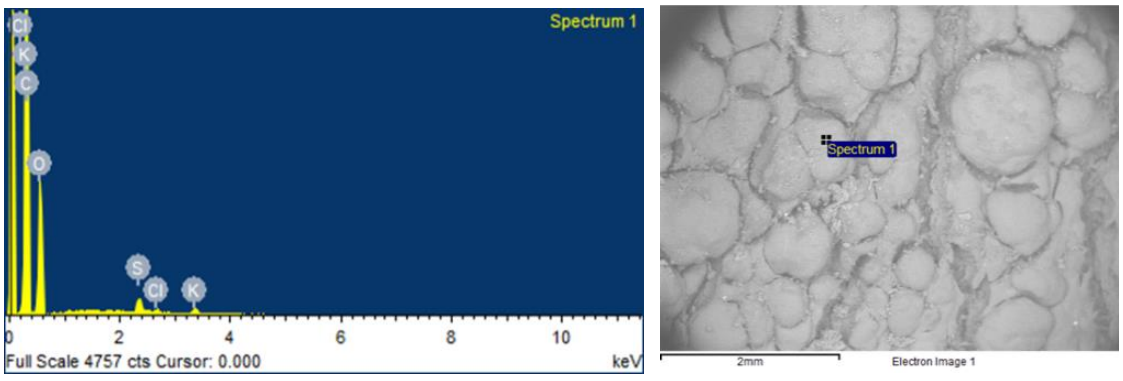

Figure 4. Elementary analysis of coconut shell CKCS.

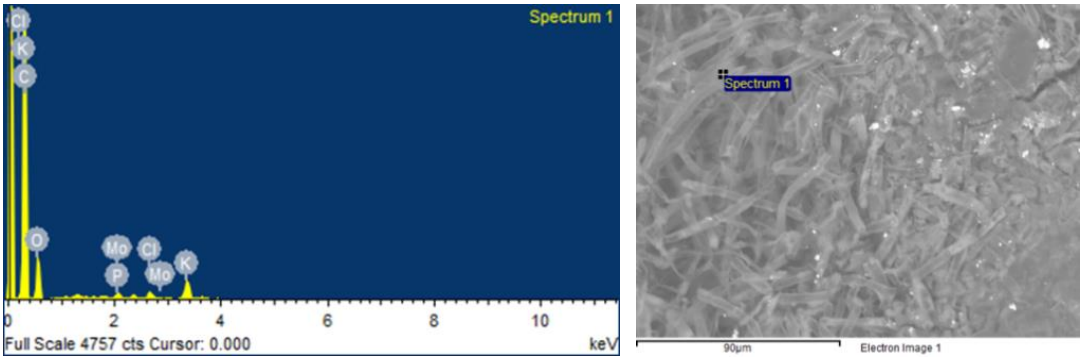

Figure 5. Elementary analysis of coconut shell CYCS.

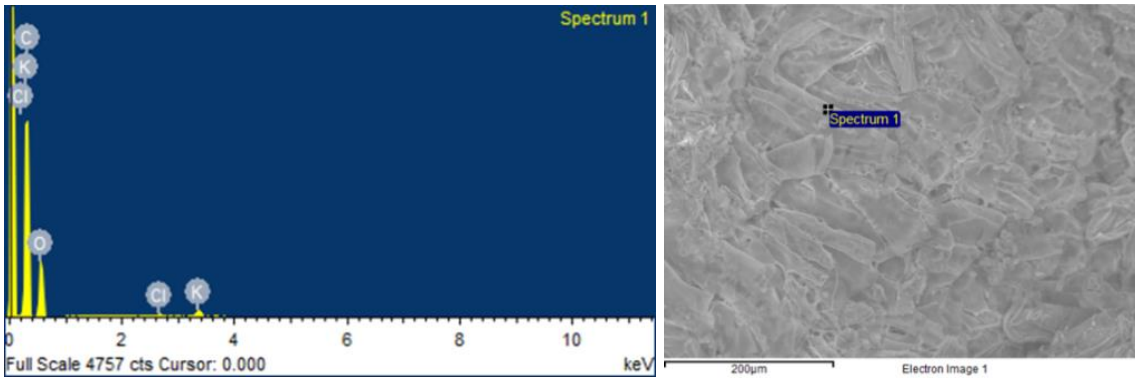

Figure 6. Elementary analysis of coconut shell CRCS.

CONCLUSIONS

In conclusion, CKCS carbon composites show the good achievement for tensile behaviour because they have the better results for tensile stress, tensile strain and tensile modulus when compared with CRCS and CYCS carbon composites. From the results it was obtained that, the toughness of the samples especially CKCS carbon composite increased when rich with the carbon, silicon and oxygen contents. The maximum tensile stress was led by CYCS sample with 18MPa but CKCS has a continuing higher stress with 16MPa for 15wt.% carbon content.

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ELECTRON CONTAMINATION MEASUREMENTS FROM THE MAGIC PLATE: A SILICON ARRAY DETECTOR

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ABSTRACT

The purpose of the present study is to characterize electron contamination produced by a Magic Plate silicon array detector when placed in the treatment head of a medical linear accelerator. Percentage depth dose measurements in the buildup region of a 6MV x-ray beam were studied with and without Magic plate placed in the beam. Different thickness layers of solid water were also placed on the Magic Plate to find the threshold of electron contamination in the beam. Doses at different field sizes and source surface distance's (SSD's) were also measured in this study. Based on the results, there are no noticeable differences in depth dose curve for the beam with the presence of the Magic plate as well as different thickness of solid water (up to 10 mm) place on Magic plate during irradiation at 100 cm SSD. However, there were small increases in surface dose at short SSD. For example, for a 10 x 10 cm^2 field, the surface dose at 70 cm SSD was 42.3% with Magic Plate and 1 cm water while the open field dose without the Magic Plate was 27.7%.

Keywords: Electron contamination; Dosimetry; Silicon diode array; IMRT; surface dose.

INTRODUCTION

Based on World Health Organization (WHO) statistics, cancer is a leading cause of death worldwide, accounting for 7.6 million deaths (around 13% of all deaths) in 2008 and this number is predicted to continue rising with an estimated 13.1 million deaths per annum by 2030 (Delaney, Jacob, Featherstone & Barton, 2005). Radiotherapy is one choice of treatment for cancer. Currently, it is predicted that approximately 52.3% of all new cancer cases will require radiotherapy as part of their treatment (Edwards, Mountford, & Moloney, 2006). Thus, radiotherapy is an important treatment modality for patients diagnosed with cancer. Compared to chemotherapy, radiotherapy is precisely delivered to only one particular location, so damage to healthy cells is limited to just the surrounding area. One of the Hallmarks of Megavoltage radiotherapy is the skin sparing effect. However, there is a small amount of unwanted radiations which can cause a small increase in skin dose to the cancer patients receiving Megavoltage radiotherapy treatments. The tissue surface incident by a radiotherapy x-ray beam will be contaminated by secondary electrons which are generated by interactions between the x-ray beam and the components in the head of the linear accelerator (Metcalfe, Kron & Hoban, 2007). These radiations will contribute to unnecessary skin dose to cancer patients that receive radiation therapy. Thus, demands for better treatments and improved modalities that maximize tumour control and to minimize damage to healthy tissue are important.

Dosimetry is the science of measuring radiation dosage. In radiotherapy dosimetry, a high degree of accuracy, reliability and reproducibility is necessary for safe and effective radiation treatment of cancer patients. In radiation delivery techniques such as static gantry intensity-modulated radiation therapy (IMRAT), volumetric intensity modulated arc therapy (VMAT), TomoTherapy, complex QA verification methods for dosimetry are required. Nowadays, one of the QA devices, a 2D silicon array detector (Magic Plate) is becoming available as a dosimetry prototype for measuring radiation dosage from complex deliveries such as IMRT. The 2D diode array (Magic Plate) developed at the Centre for Medical Radiation Physics (CMRP); University of Wollongong is based on epitaxial technology and "drop-in" mounting technique. This Magic Plate is designed as dosimetry device for IMRT/VMAT QA (Wong & Fuduli, et al., 2012). The objective of this study was to characterize electron contamination produced by a Magic Plate silicon array detector when placed in the treatment head of a medical linear accelerator

Magic Plate

The use of electronic 2D arrays detector is increasingly gaining widespread use as they provide competent means of calculating doses at several locations in the field, given the real time feedback and carrying out planar dose comparison at the same time (Wong et al., 2012). There are three elementary approaches in IMRT QA verification using 2D array detector. The first approach is with the 2D detector array positioned on the linear accelerator couch or mounted onto the gantry head with special jig without presence of patient. This approach is the most common approach as patient specific and usually performed prior to the delivery of the first IMRT treatment.. The second approach, 2D detector array positioned between the mulitileaf collimator (MLC) and the patient acting as a transmission detector for on-line and in-vivo measurement can achieve the aims of IMRT QA for correct MLC functioning in pretreatment QA verification and throughout the whole treatment duration. The third approach is carried out with the 2D detector array positioned downstream of the patient, such as using EPID or mounting a detector array on the EPID. This approach allows daily patient variability could easily mask any dose delivery error (Wong et al., 2012).

Design of Magic Plate

Magic Plate is aimed to function as a 2D transmission detector as well as a planar detector for dose distribution measurements in a solid water phantom for the dosimetric verification of IMRT treatment delivery. The Magic Plate packaging needs to be modified to allow each of these applications. The Magic Plate consists of 11 x 11 epitaxial silicon diode mounted on a 0.6 Kapton substrate. The epitaxial, comes from the Greek word, epitaxy which means to arrange upon in an orderly manner (Taylor, 2004) involve with the process of growing a high quality thin epitaxial film on top of a heavily doped bulk silicon wafer which act as a crystal for the epitaxial to grow and then serve as a supporting structure. The epitaxial diode is an alternative to a conventional silicon detector due to the thin epitaxial layer which is deemed to be more radiation hard. The epitaxial layer of Magic Plate diode is a 50μm thick p-Si (100 Ωcm) grown on top of 375μm thick, very low resistivity (0.001 Ωcm) p+ substrate. The sensitive volume of the individual element defined by the n+ region is 0.5 x 0.5 x 0.5

mm^3, while the size of the die is 1.5 x 1.5 mm^2. The detector pitch is 1 cm. Diodes were produced by ion implantation technology (Wong et al., 2012).

The "drop-in" mounting of the epitaxial diode attempts to minimize energy dependence and improve the angular response of the diodes. This was achieved by using thin aluminum contacts on the periphery of the 0.5 x 0.5 mm^2 n+ ion implanted regions using a special technology. The lead of the diode is fully embedded in the Kapton substrate. The diode's face is aligned with the Kapton substrate's front surface. This technology avoids the use of high Z metal contacts (wire bonding) above the sensitive area and copper contact plate below the die (Wong et al., 2012).

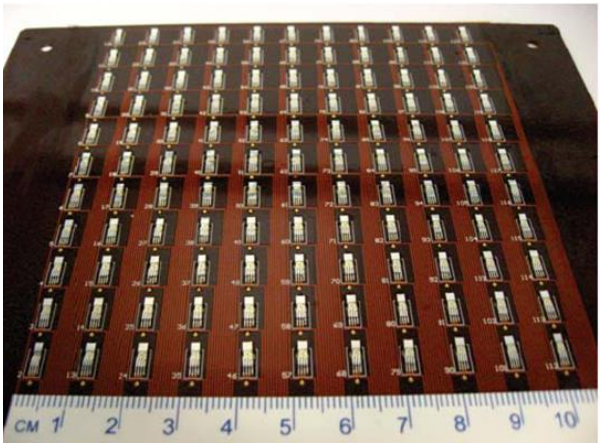

Figure 1. 2D array Magic Plate (Wong et al., 2012).

ELECTRON CONTAMINATION

The side effect of radiation therapy originate from the production of chemicals in irradiated cells, reduced or impaired organ or tissue function, as well as skin injury from excess amount of exposure at the skin level. A large contribution to this skin dose rises from electron contamination, or secondary electrons produced at sites outside the patient surface that strike the patient's skin. All conventional LINAC produced x-ray beams contain such contamination (Metcalfe et al., 2007). Electron contamination occurs when a radiotherapy x-ray beam is contaminated by electrons generated between the x-ray beams by the components in the head of the LINAC (Oborn, 2006). This can contribute to an increase in skin dose to cancer patients receiving radiotherapy. There are lots of factors that define the magnitude of dose from electron contamination. In the prior study of characterization of electron contamination in megavoltage photon beam in different clinical situations shows that electrons generated in the treatment head were more energetic and more crucial in larger field sizes, shorter source surface distance (SSD), and greater depths [8, 9]. This difference is much more pronounced for the higher energy beam (18 MV) than for the lower energy beam (6 MV) (Medina et al., 2005). In addition, by using tray as beam modifier will also increase electron contamination (Allahverdi et al., 2011).

The use of the Magic Plate as a transmission detector may also attenuate the beam or influence the secondary electron contamination of the photon beam. In the recent study, the presence of the Magic Plate as a transmission detector shows in increase of surface dose and the dose within the buildup region of the depth dose curve. The surface dose and build up region under the Magic Plate was compared with the

open field measurements collected with a parallel plate ionization chamber. The increased surface dose and dose within the buildup region was attributed to the increased electron contamination due to the presence of the Magic Plate. For the 20 x 20 cm^2 field size, the surface dose increased by 3.4% and 7.3% for the SSD of 90 and 80 cm, respectively. The electron contamination increases with larger field size and with shorter SSDs. For the largest field size investigated at the SSD of 80 cm, the presence of the Magic Plate would increase the dose to the superficial tissues by 12.1% (Wong et al., 2012).

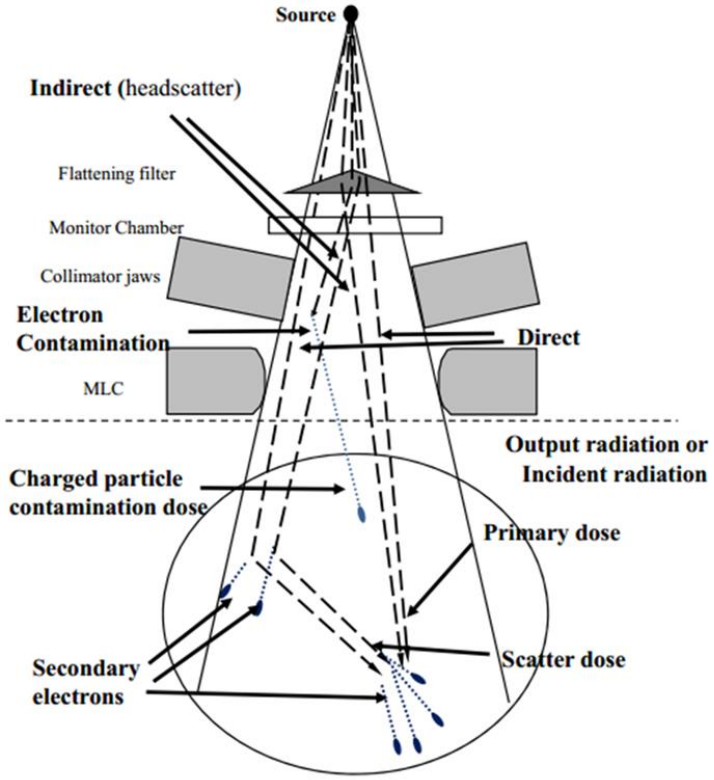

Figure 2. Electron contamination generated in LINAC head (Zhu et al., 2009).

METHODOLOGY

To measure the electron contamination, surface dose and the buildup region (0–100 mm depth) of a 6 MV photon beam is measured. Field sizes of 10 x 10cm^2 is set at sources to surface distances (SSDs) of 100 cm. Magic plate is used in transmission mode. The magic plate is wrapped with aluminium foil to protect the magic plate from dust and other accidental contacts. The aluminium foil also can shield the detector from ambient lights. The whole assembly is then mounted into the Linac accessory slot which is just below the Linac jaw. The measurements are made in a solid water phantom using a Markus type parallel plate ion chamber. Markus type chambers are known for their over-response due to the small guard ring. For the first experiment, measurements with and without the presence of Magic plate is taken and is then normalized to the depth of maximum dose. In the second experiment, different thickness of solid water (2 mm, 5 mm and 10 mm) were placed on the Magic Plate. It is important to verify the electron contamination as the extra layers of solid water increase the sensitivity of the detector as more photons and electrons are produced in the buildup material. The material also provides a barrier for physical protection of the device.

In the third experiment, same parameter setting as previous experiments is used. Two field sizes are used to measure the electron contamination in this experiment which is 10 x 10 cm^2 and 14 x 14 cm^2. To measure the electron contamination, surface dose at depth of 0 and 15 mm are taken at different SSDs from 70 cm to 100 cm are measured.

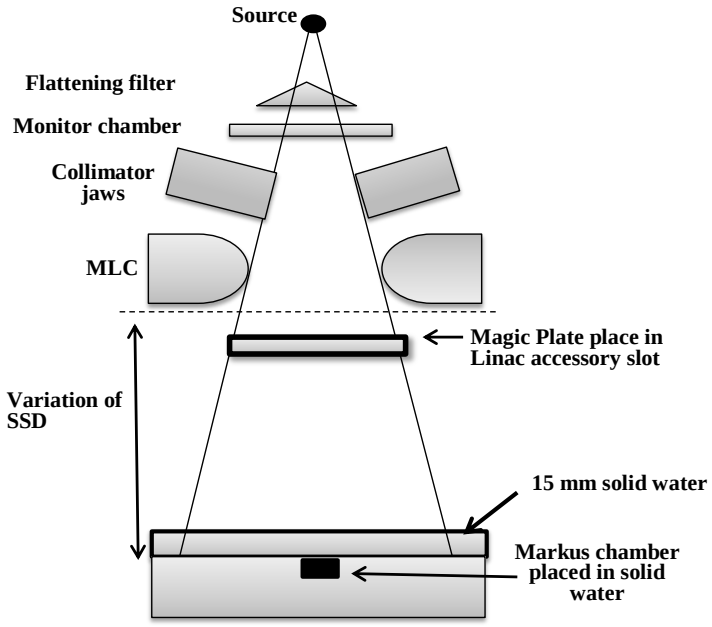

Figure 3. Experimental setup to measure electron contamination.

Calculating True Depth Dose

During experiments, the ionisation measurements taken were not the exact depth dose. Few factors should be taken into account in calculating the true depth dose from these experiments. Factors that should be taken into account include the charge of electrons entering through the side wall of the Markus chamber and the effect of the distance between the collector edges to side wall (Rawlinson, Arlen & Newcombe, 1992). Besides that, the over response from the side walls is mainly dependent on the ratio of the electrode separation (s) to the diameter of wall (w), wall density and wall angle. Thus in calculating the true depth dose Rawlinson's modified Velkey formula are used which take into account the chamber wall diameter, size of the guard ring, separation of electrode and the material of the chamber (Chen, Gupta & Metcalfe, 2010). The guard ring is designed in parallel plate chamber to collect some of the low energy scatter. However, in order to keep the device compact there is always some unwanted ionisation collected. The Velkey formula empirically accounts for this effect as follows:

$$P(d,E) = P'(d,E,G) - \xi(d,E,G) \quad (1)$$

where P(d,E) is the true percentage depth dose and P'(d,E,G) is the measured percentage depth dose.

$$\xi(d,E,G) = \xi(0,E,G) \times e^{-4.0d/dmax} \quad (2)$$

where, $\xi(d,E,G)$ is over respond correction factor.

$$\xi(0,E,G) = c(E) \times (s/w) \times \rho^{0.8} \quad (3)$$

where, s is the electrode separation, w is the diameter wall and ρ is the mass density of chamber wall. In this study, c(E) for 6 MV beam based on Rawlinson study is equal to 27%, the electrode separation is 1 mm, diameter wall is 9 mm and mass density of chamber wall is 1.189 g/cm^2 (Chen, Gupta & Metcalfe, 2010).

RESULTS AND DISCUSSION

Measurement of Electron contamination with and without present of Magic Plate

Electron contamination occurs when a radiotherapy x-ray beam is contaminated by electrons generated between the x-ray beams by the components in the head of the LINAC. Based on the results (figure 4), we can see that, the amount of dose is slightly larger with the presence of Magic Plate in the beam than during the open field. However, the difference as small that not even accounts 1%. This may be caused by the condition of Magic plate during the experimental setup. The aluminium foil that wrapping the Magic Plate to protect the Magic plate from dust and other accidental contact as well as shielding it from ambient lights, may remove low energy photon of the beam during experiments. Thus, true dose amount is not acquired during the experiment. However, as mentioned before, there is still evidence of increase in amount of dose with the presence of Magic Plate in the beam. This shows that, Magic Plate also plays a role in contribution of electron contamination during irradiation.

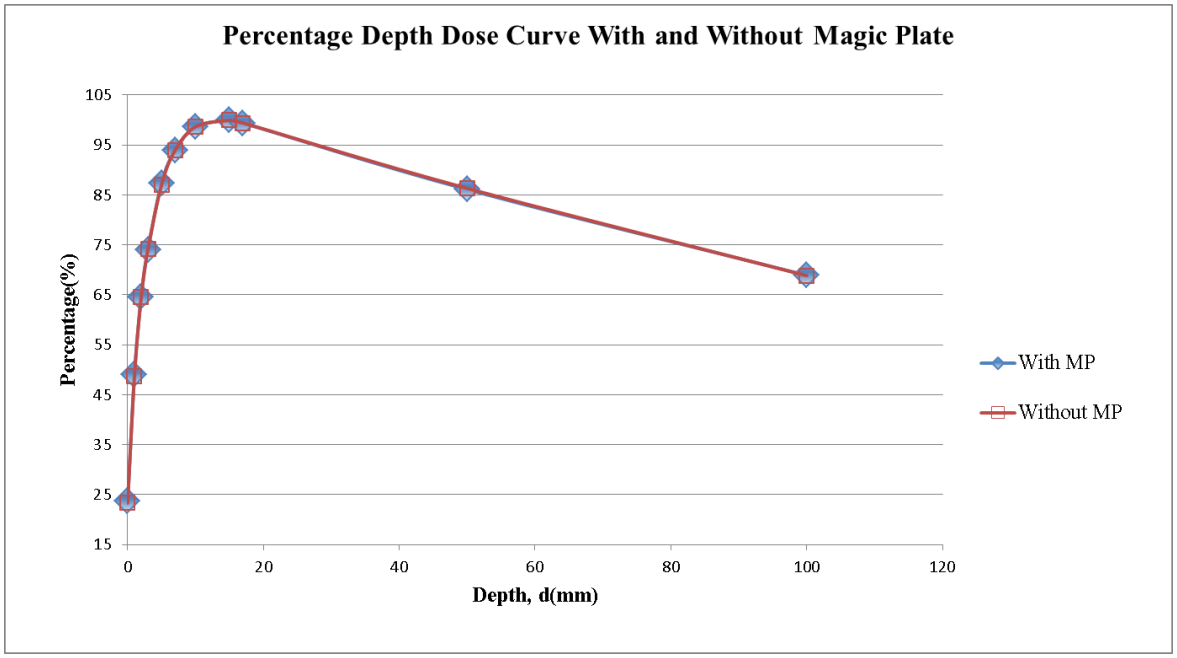

Figure 4. Graph shows data taken in open filed and when Magic plate presence in the beam.

Measurement of Electron Contamination with different thickness of solid water place on Magic Plate.

Based on the results (Figure 5), we can see that amount of dose increases as thickness of solid water placed on Magic Plate increases. This is due to more interaction occurring between beam and solid water in Linac head plus with interaction with Magic Plate. These contribute to more surface dose. However, as previous experiments, the difference of increment of dose is too small (<1%).

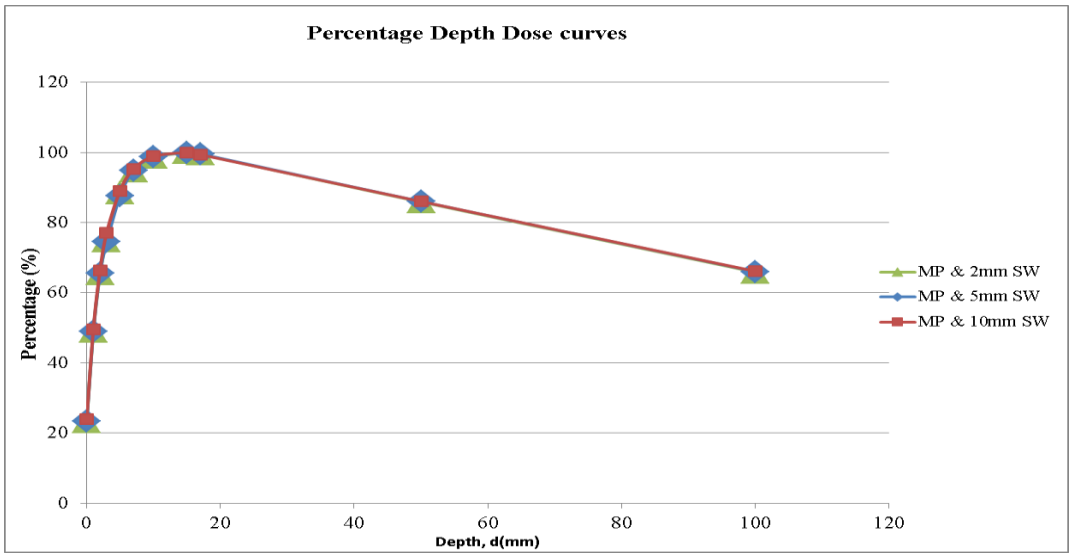

Figure 5. Graph shows data taken with different thickness of solid water placed on Magic Plate.

Measurement of Electron Contamination with variation of source surface distances (SSDs).

Based on the results (figure 6), we can see the presence of Magic Plate (with 1cm solid water) shows in increase of surface dose and the dose within buildup region of depth dose curve. In the field size of 10 x 10 cm^2, at SSDs of 70 cm, 80 cm, 90 cm and 100 cm, there are increment of dose about 15%, 5%, 1% and 1% respectively with the presence of Magic Plate in the beam. On the other hand, in the field size of 14 x 14 cm^2, at SSD 70 cm, 80cm, 90 cm and 100 cm, there are increment of dose about 22%, 7%, 2% and 1% respectively with the presence of magic plate. These result shows that, electron contamination increases with larger field size and with shorter SSDs.

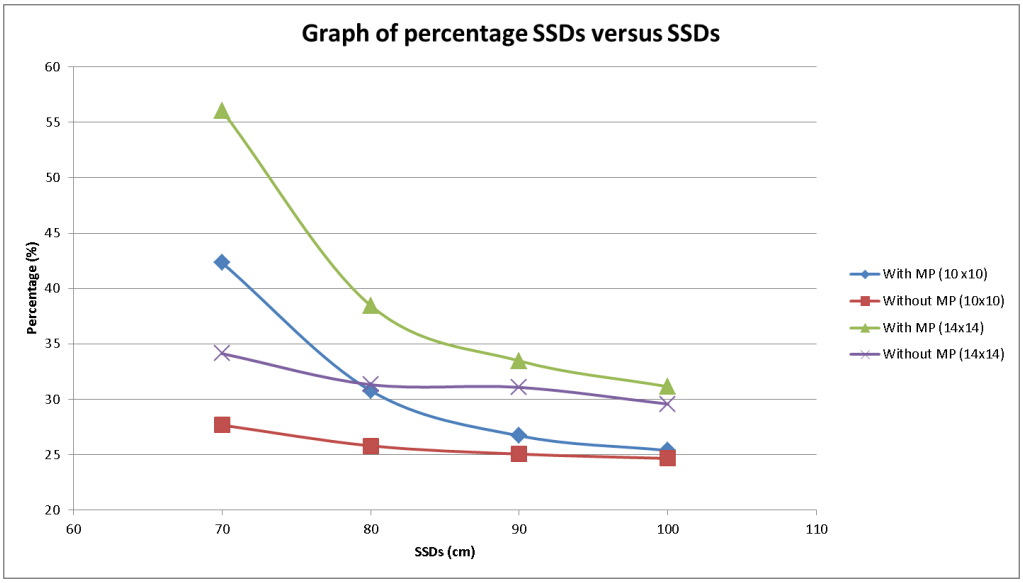

Figure 6. Graph shows the percentage ratio of doses at different SSDs in 10 x 10 cm^2 and 14 x 14 cm^2 fields.

CONCLUSION

Based on the results from this study, there is no discernable increase in electron contamination with the presence of Magic plate alone. The amounts of difference with the presence of Magic Plate and various thickness of solid water on the Magic Plate in the beam are small. However, the dose measured still shows a small increment in surface dose at short SSD. This is probably due to the near Gaussian distribution of the electron contamination component having less distance and angle to disperse at short SSD. Besides that, as field sizes increase, this is consistent with more surface area of the magic plate being present for electron contamination induction due to the wider field size. While this prototype could only measure out to ~14 x 14 cm^2 field size the electron contamination would likely increase for larger prototypes that extend out to the full filed 40 x 40 cm^2 size of Linac. If new Magic Plate prototypes are produced with a larger array matrix for wide field in IMRT dosimetry, these factors should be taken into account so that electron contamination or surface dose can be accounted for. This will ensure surface dose to the patient is monitored as a known quantity. In general the electron contamination from the Magic Plate was extremely low and there would be very little concern about these low levels if the device is placed in the beam during patient treatments. The extra solid water protective and buildup layers (up to 1 cm) on the Magic Plate would also likely produce low enough increases in electron contamination that they too could be included during patient treatments. It should be noted thought that as the buildup material is increased the transmission factor becomes significant (i.e. 0.948 for Magic Plate plus 10mm solid water).

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A HOMOGENEOUS CHARGE COMPRESSION IGNITION ENGINE: AN INTRODUCTION

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ABSTRACT

Homogeneous charge compression ignition (HCCI) engine technology is relatively new and has not matured sufficiently to be commercialised compared with conventional engines. It can use spark ignition (SI) or compression ignition (CI) engine configurations, capitalizing on the advantages of both: high engine efficiency with low emissions levels. The HCCI engines can use a wide range of fuels with low emissions levels. Due to these advantages, the HCCI engines are suitable to be used in a hybrid engine configuration, where it can reduce the fuel consumption even further. However, the HCCI engines have some disadvantages such as knocking and low to medium operating load range, which need to be resolved before the engine can be commercialised. Therefore, a comprehensive study has to be performed to understand the behavior of HCCI engines.

***Keywords*:** Diesel; HCCI; Gasoline; Natural Gas; Hydrogen

BACKGROUND

The greenhouse effect is a worldwide issue as more and more greenhouse gases are released into the atmosphere, leading to global climate change. The effects include an increase in temperature, unstable weather and an increase in ocean levels, resulting in ice melting in the North and South Poles (Bates *et al.*, 2008, Graham *et al.*, 1990, Houghton *et al.*, 2001). This has become a global issue. Members of the Copenhagen Climate Conference in December 2009 (Bodansky, 2010) unable to reach an agreement on climate change. The increase of surface air temperature due to global warming has been simulated by Rob (2005) from NASA (see Figure 1), showing an increase in surface air temperature from 1960 to 2060. According to the report of the World Resources Institute (Jonathan 2006), transportation accounted for about 14% of the global greenhouse gases in 2000, making it a major contributor to global climate change and equivalent to 18% of global CO_2 emissions. Thus, it is imperative to minimise the emissions level from the transportation sector. To counter this issue, many automotive manufacturers are developing electric, fuel-cell or hybrid engines. Electric vehicle is driven by an electric motor, with the energy supplied by a high capacity battery stored in the car trunk or under the car body. The operation of the fuel-cell engine is similar to the electric vehicle by using an electric motor to drive the wheel. However, the difference is on the electricity generation method. Most fuel-cell driven vehicles use hydrogen and oxygen to generate electricity (Ogden *et al.*, 1999, Trimm and Onsan,

2001). Then, this electric energy will be stored in a high capacity battery and is used to drive the electric motor. Hybrid vehicle uses a combination of the conventional internal combustion (IC) engine and electric motor. The IC engine could be Spark Ignition (SI) or Compression Ignition (CI) engine, which is connected to the electric motor either in parallel or in series to drive the wheel. High capacity battery is again used to power the electric motor. Therefore, it can be summarised that the vehicle is driven by two or more power sources in hybrid configurations.

Table 1 summarises the advantages and disadvantages of those technologies and high implementation cost related to each of them leads to a slow commercialisation rate. Thus, an interim solution is required to improve the current IC engines with low implementation cost.

Table 1. Comparison of newly developed engine technology (Chan, 2002).

Engine Type	Advantages	Disadvantages
Hydrogen Fuel Cell	• Compact design • relatively long operating life • high efficiency • low temperature operation.	• Higher loads reduce efficiency considerably • high energy cost • high manufacturing cost • heavy auxiliary equipment • complex heat and water management • safety issues
Electric	• No fuel • 100% emissions free at the vehicle (substantially reduced emissions overall) • fewer moving parts to wear out.	• Limited operating battery ranges • long recharge time • battery size and weight issues • high battery replacement costs • limited charging facilities
Hybrid	• Lower emissions level • better fuel economy over conventional engines.	• Unachievable break-even point before replacing the battery • high and costly maintenance • battery size add the extra weight to the vehicle

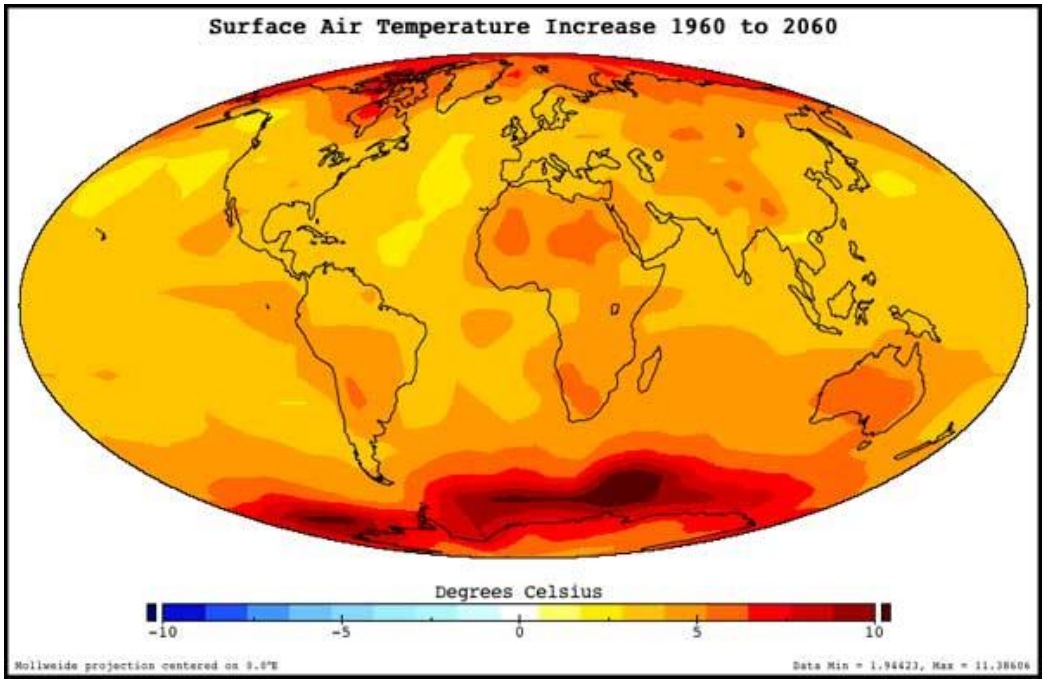

Figure 1. Simulated surface air temperature increase by the year 2060 (Rob, 2005).

INTRODUCTION

IC engines are widely used in numerous applications: vehicle engines, power generation and ships. The emissions generated from these applications have a high impact on the environment, thus alternative solutions have been investigated to achieve low emissions levels (Chan, 2002, Cho and He, 2007, Jonathan, 2006, Taylor, 2008). A new mode of combustion is being sought in order to reduce the emissions levels from these engines: a potential candidate is the Homogeneous Charge Compression Ignition (HCCI) engine. Figure 2 shows the differences among SI, CI and HCCI engines, where SI engines have a spark plug to initiate the combustion with a flame front propagating across the combustion chamber. CI engines have a fuel injector to inject the diesel and the combustion takes place in a compressed hot air region. HCCI engines on the other hand, have no spark plug or fuel injector and the combustion starts spontaneously in multiple locations. High engine efficiency can be achieved with low NO_x and soot emissions.

In HCCI combustion, a homogeneous mixture of air and fuel is compressed until auto-ignition occurs near the end of the compression stroke, followed by a combustion process that is significantly faster than either CI or SI combustion (Rattanapaibule and Aung, 2005). Epping et al. (2002) and Christensen and Johansson (1998) reported that the HCCI technology, using iso-octane as a fuel, has improved the engine efficiency by as much as 37% given a high compression ratio (18:1) and maintains low emissions levels. The efficiency and compression ratio are in the range of CI engines. The technology can be implemented by modifying either SI or CI engines using any fuel or combination of fuels. The air/fuel mixture quality in HCCI engines is normally lean, it auto-ignites in multiple locations and is then burned volumetrically without discernible flame propagation (Kong and Reitz, 2002). Combustion takes place when the homogeneous fuel mixture has reached the chemical activation energy and is fully controlled by chemical kinetics (Najt and Foster, 1983) rather than spark or injection timing.

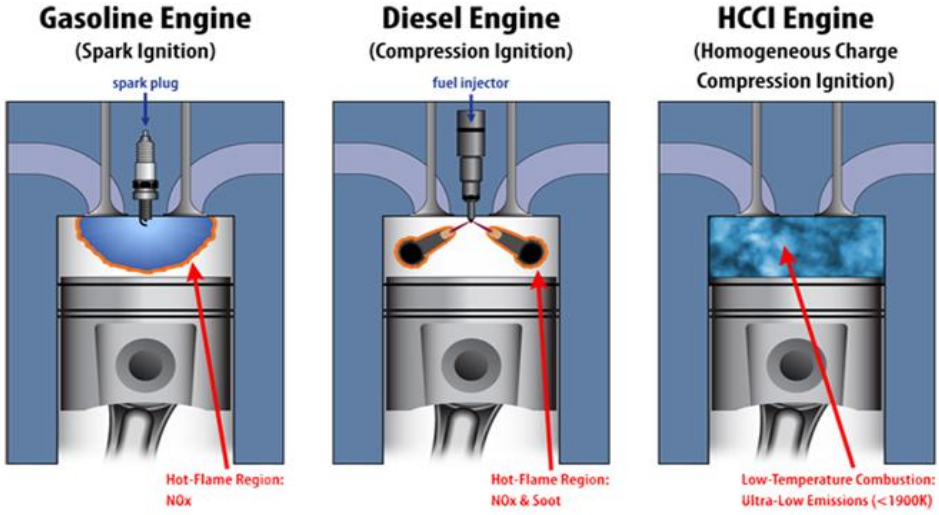

Figure 2. The differences among SI, CI and HCCI engines, reproduced from (William and Charles, 2011).

Since the mixture is lean and is fully controlled by chemical kinetics, there are new challenges in developing HCCI engines: difficult to control the auto-ignition of the mixture and the heat release rate at high load operation, achieve cold start, meet emission standards and control knock (Kong and Reitz, 2003, Soylu, 2005). The advantages of using HCCI technology in IC engines are:

1. High efficiency relative to SI engines - approaching the efficiency of CI engines due to the ability of these engines to use high compression ratio (CR) and fast combustion (Killingsworth *et al.*, 2006, Mack *et al.*, 2009);
2. The ability to operate on a wide range of fuels (Aceves and Flowers, 2004, Mack *et al.*, 2009, Christensen *et al.*, 1997); and
3. The ability to be used in any engine configuration: automobile engines, stationary engines, heavy duty engines or small sized engines (Epping *et al.*, 2002, Hiltner *et al.*, 2002, Kawano *et al.*, 2005).

On the other hand, HCCI engines have some disadvantages such as high levels of unburned hydrocarbons (UHC) and carbon monoxide (CO) (Kong and Reitz, 2003, Nathan *et al.*, 2010, Yap *et al.*, 2006). Knocking is also occurred under certain operating conditions and reduces the operating range of the engine (Andreae *et al.*, 2007, Jun *et al.*, 2003, Kong and Reitz, 2003, Nathan *et al.*, 2010, Yelvington and Green, 2003).

Emissions regulations are becoming more stringent and NO_x and soot emissions levels in HCCI engines have been greatly reduced without sacrificing efficiency, which is close to that of CI engines (Nathan *et al.*, 2010). However, knocking is still the major issue because of its sudden onset and results in a bad engine performance. Knocking is due to premature combustion where the ignition takes place before the piston reaches top dead centre (TDC) and it reduces engine reliability due to high vibration effects. Recently, hybrid engines have been developed by many automotive manufacturers due to its advantages, and the HCCI engine has the potential to replace the IC engine used in a hybrid configuration, which could reduce the emissions levels further. Thus, it is

important to investigate the HCCI engine's performance because it can be used in the near future.

State of the Art Current Internal Combustion Engines

Producing homogenous mixtures to achieve near-complete combustion is a common goal that will lead to the development of low polluting engines. Some technologies including Fuel-Stratified Injection (FSI), Turbo-Stratified Injection (TSI) and HCCI, are used to improve the combustion efficiencies by introducing the homogeneous mixture. FSI and TSI are commercially used by the Volkswagen Aktiengesellschaft (AG), which consists of other child companies: Audi, Skoda, Seat, Bugatti, Lamborghini, Bentley and Scania (Volkswagen, 2009). FSI uses direct injection fuel with high injection pressure, where the evaporating fuel has a significant cooling effect on the cylinder charge (Audi, 2012). This effect helps in reducing the knock and therefore higher compression ratio can be used. The air enters the combustion chamber at a certain angle by using a moveable flap inside the intake manifold (Wurms *et al.*, 2003), while fuel is directly injected during the intake stroke. The fuel injector is located close to the inlet valve in the cylinder head. With the help of the piston crown design, the air will experience tumbling effects inside the chamber. This in turn will help the fuel mix with air homogeneously. TSI engines, on the other hand, uses a high intake pressure (using multipoint injectors) on an FSI engine (Böhme *et al.*, 2006). This allows the fuel to mix homogeneously with the air during the compression stroke. The pressurised intake air will assist the combustion and therefore produce better efficiency, allowing smaller engines to be built with power and torque similar to that of bigger engines. The first engine to use direct injection technology to stratified charge engine was the Texaco combustion process (Barber *et al.*, 1955), as reported by Takagi (1998). HCCI engines can be considered as new technology (Yao *et al.*, 2009) even though the research was initially undertaken by Onishi et al. (1979). Researchers worldwide are investigating HCCI engines as this technology has not yet been sufficiently developed and commercially available. General Motors (GM) corporation has unveiled a prototype car with a gasoline HCCI engine, which could cut fuel consumption by 15% (Premier, 2007). The engine is able to virtually eliminate NO_x emissions and lower throttling losses, which improves fuel economy.

Gasoline Operated HCCI Engines

Gasoline could be operated in HCCI mode on its own, however, it would be unstable in a high load operating range. High load difficulties are the common problem for HCCI engines regardless of the fuel being used. The solution for this issue for gasoline fuel is to operate the engine in HCCI mode in the medium load range, and switch to SI mode in the high load range (Yingnan *et al.*, 2010). Wang *et al.* (2006) studied the gasoline HCCI engine with secondary injections and reported that the operating load range could be extended by using two-zone HCCI mode, which utilises secondary injections. However, the two-zone mode yields higher NO_x emissions due to fuel-rich zone developed in the chamber. Iso-octane is generally used as a gasoline surrogate fuel in numerical studies due to its high octane rating. Higher octane numbers cause difficulties in achieving the HCCI mode (Hosseini and Checkel, 2009). Thus the ignition has to be controlled using other means. The use of high octane number fuels, such as gasoline, in a low CR engine allows the engine to be switchable to SI mode in a high load range

(Fuerhapter *et al.*, 2004). It is found that a high CR engine (as high as 18:1) has advantages by producing ultra-low NO_x emissions (1ppm) and higher thermal efficiency (43%) at a fixed operating condition (John and Magnus, 2002).

Gasoline can also be mixed with diesel to operate in HCCI mode. A study by Kim and Lee (2006) on the effect of multiple fuels on emissions showed that the combination of diesel and gasoline (diesel is direct injected while gasoline is port injected) is an effective way to reduce NO_x levels, with the increase of premixed ratio. The premixed ratio is defined as the energy of premixed (port injected) fuel to the energy of total fuel (direct and port injected). Zhong et al. (2005) also studied the effect of blended fuels between gasoline and diesel, and reported that UHC and NO_x were significantly reduced throughout the HCCI engine load ranges. The purpose of blending gasoline and diesel is that gasoline has a high volatility and is easy to vaporise, thus can be used to form a homogeneous mixture. Gasoline also has a high octane number, where higher numbers show higher resistivity to knocking. Diesel on the other hand has good ignitability and fast combustion due to its high cetane number. Table 2 compares the characteristics between the gasoline and diesel fuels, where for the selected gasoline (octane number 98) the heating values are almost similar between those fuels.

Table 2. Characteristics between gasoline and diesel fuels (Kim and Lee, 2006).

	Gasoline	**Diesel**
Octane number	98	-
Cetane number	-	54
Higher heating value (kJ/kg)	47 300	44 800
Lower heating value (kJ/kg)	44 000	42 500
Boiling point (K)	468	553
Density (kg/m^3)	750	814
Stoichiometric air-fuel ratio	14.6	14.5

Natural Gas and Hydrogen with Diesel in HCCI mode

The combination of natural gas or hydrogen with diesel reported to yield low emissions and to some extent increase the engine efficiency, either in HCCI or CI combustion mode (de Risi *et al.*, 2008, Hairuddin *et al.*, 2010, Saravanan *et al.*, 2008a, Saravanan *et al.*, 2008b, Verhelst and Wallner, 2009). Diesel alone is not suitable for HCCI engines due to its low volatility and high propensity to auto-ignite while natural gas has a high resistance to auto-ignition as reported by Kong (2007). Combinations of high octane number fuels (such as natural gas and hydrogen) with high cetane number fuels (such as diesel) are able to increase the engine durability, and under certain operating conditions reduce emissions levels such as soot, HC, CO and NO_x (Szwaja and Grab-Rogalinski, 2009, Tomita, 2004, Tomita *et al.*, 2001, Tomita *et al.*, 2002). It was also reported that these combinations have a high thermal efficiency under early injection timing (Tomita, 2004, Tomita *et al.*, 2002). Fuels with a higher octane number have better resistance to knocking while fuels with a higher cetane number have a shorter ignition delay time, thus providing more time for the fuel to complete the combustion. Therefore, a combination of both (high cetane number fuels and high octane number fuels) provides soft engine run (Szwaja and Grab-Rogalinski, 2009), whereby the mixture can be operated at high CR and has a longer combustion duration.

Hydrogen has a high octane number (approximately 130) and a high Lower Heating Value (LHV) (119.93 MJ/kg). Its combination with diesel helps to increase engine efficiency (Saravanan *et al.*, 2008a) and control the auto-ignition point in HCCI engines (Szwaja and Grab-Rogalinski, 2009). Natural gas, on the other hand, has a higher auto-ignition temperature and it can be used in high CR engines (Akansu *et al.*, 2004). Table 3 compares the physical and chemical properties of diesel with natural gas and hydrogen.

Table 3. Diesel Properties Compared to Hydrogen and Natural Gas (Liu and Karim, 2008, Saravanan and Nagarajan, 2010, Saravanan *et al.*, 2008b, Verhelst and Wallner, 2009).

Properties	**Diesel**	**Hydrogen**	**Natural Gas**
Main component	$C_{12}H_{23}$	H_2	Methane (CH_4)
Auto-ignition temperature (K)	553	858	923
Lower heating value (MJ/kg)	42.5	119.93	50
Density (kg/m^3)	833-881	0.08	0.862
Molecular weight (g/mol)	170	2.016	16.043
Flammability limits in air (vol%) (LFL–UFL)	0.7-5	4-75	5-15
Flame velocity (m/s)	0.3	2.65-3.25	0.45
Specific gravity	0.83	0.091	0.55
Boiling point (K)	453-653	20.2	111.5
Cetane number	40-60	-	-
Octane number	30	130	120
CO_2 emissions (%)	13.4	0	9.5
Diffusivity in air (cm^2/s)	-	0.61	0.16
Min ignition energy (mJ)	-	0.02	0.28

From the Table 3, hydrogen has the highest LHV or Lower Calorific Value (LCV) compared to both diesel and natural gas, which means it releases a high amount of energy during combustion and thus produces the highest flame speed. A wide range of the flammability limits in air allows a wider range of engine power outputs through changes in the mixture equivalence ratio. Flammable mixtures of hydrogen can go from as lean as $\lambda = 10$ to as rich as $\lambda = 0.14$ (Verhelst and Wallner, 2009), where λ is the air-to-fuel ratio actual divided by the air-to-fuel ratio stoichiometric.

CONCLUSION

Therefore, it is feasible to use gasoline, diesel, natural gas, hydrogen or a combination of those in HCCI engines, because the engine could be operated in a wide range of fuels. From practicality point of view, the HCCI engine could be used in a hybrid configuration, where it might help reduce the fuel consumption even further. Many studies show the HCCI engine has a low NO_x emissions, soot and particulates. However, HCCI engines still have unresolved issues, which are knocking and high levels of unburned HC and CO emissions. Further studies have to be performed in order to solve these remaining issues. To achieve this, the numerical method is proposed for early study because it has great advantage over experiments in terms of cost and time.

To this end, a simulation model has been developed to investigate the combustion behavior and, once completed, it has to be validated against experiments.

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DISCRETIZATION OF THREE DIMENSIONAL NON-UNIFORM GRID: CONDITIONAL MOMENT CLOSURE ELLIPTIC EQUATION USING FINITE DIFFERENCE METHOD

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ABSTRACT

In most engineering problems, the solution of meshing grid is non-uniform where fine grid is identified at the sensitive area of the simulation and coarse grid at the normal area. The purpose of the experiment is to ensure the simulation is accurate and utilizes appropriate resources. The discretization of non-uniform grid was done using Taylor expansion series and Finite Difference Method (FDM). Central difference method was used to minimize the error on the effect of truncation. The purpose of discretization is to transform the calculus problem (as continuous equation) to numerical form (as discrete equation). The steps are discretizing the continuous physical domain to discrete finite different grid and then approximate the individual partial derivative in the partial differential equation. This discretization method was used to discritize the Conditional Moment Closure (CMC) equation. The discrete form of CMC equation can be then coded using FORTRAN or MATLAB software.

***Keywords*:** finite difference method, Taylor series, conditional moment closure, non-uniform grid, FORTRAN, MATLAB

INTRODUCTION

The fossil fuel is predicted to be the main energy resources for the next 30 years (IEA, 2009; Maczulak, 2010) Combustion of fossil fuel remains the main source of energy for power generation, transportation, domestic and industrial heating. The demand is increasing but the adequacy of the reserved is still questionable (Shafiee and Topal 2009), Combustion process not only produces heat that convert to useful energy, but also produces pollutant such as oxide of nitrogen (NO_x), soot and unburned hydrocarbon (UHC) and greenhouse gases such as carbon dioxide (CO_2). The unwanted emissions can be reduced by improving the combustion process; thereby, increasing fuel economy. Besides the experimental technique, combustion modeling is becoming more important and cost effective especially in the design and development stage. The basics of the combustion process are fluid flow and chemical reaction process. The continuity equation is very important parameters in the study of fluid flow and chemical reaction. There are various forms of the continuity equations in the Cartesian, cylindrical and spherical forms. The general form in the Cartesian coordinate of continuity equation or the conservation of mass equation is

$$\frac{\partial \rho}{\partial t} + \nabla.(\rho v) = 0 \tag{1}$$

The continuity equation for 2D geometries is given by

$$\frac{\partial \rho}{\partial t} + \frac{\partial (\rho v_x)}{\partial x} + \frac{\partial (\rho v_y)}{\partial y} = 0 \tag{2}$$

where x is axial coordinate, v_x is axial velocity, y is radial coordinate and v_y is radial velocity. For the incompressible fluid flow, density is constant, the first term in the left will be zero and therefore Eq. (2) can be summarized as

$$\frac{\partial (v_x)}{\partial x} + \frac{\partial (v_y)}{\partial y} = 0 \tag{3}$$

The conservation of momentum equation is

$$\frac{\partial (\rho v_i)}{\partial t} + \frac{\partial (\rho v_i v_j)}{\partial x_j} = -\frac{\partial (p)}{\partial x_i} + \frac{\partial (\tau_{ij})}{\partial x_j} + \rho g + F_i \tag{4}$$

where p is the static pressure, ρg is gravitational force and F is other forces. Viscous stress tensor (T_{ij}) is

$$\tau_{ij} = \mu \left(\frac{\partial v_i}{\partial x_j} + \frac{\partial v_j}{\partial x_i} \right) - \frac{2}{3} \delta_{ij} \left(\frac{\partial v_k}{\partial x_k} \right) \tag{5}$$

where μ is molecular viscosity. The momentum equation for 2D geometries is given by

$$\frac{\partial (\rho v_x)}{\partial t} + \frac{\partial (y \rho v_x v_x)}{\partial x} + \frac{\partial (y \rho v_y v_x)}{\partial y} + \frac{\partial p}{\partial x} = \frac{\partial}{\partial x} \left[\mu \left(2 \frac{\partial v_x}{\partial x} - \frac{2}{3} \left(\frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y} + \frac{v_x}{x} \right) \right) \right] + \frac{\partial}{\partial y} \left[\mu \left(\frac{\partial v_x}{\partial y} + \frac{\partial v_y}{\partial x} \right) \right] + F_x \tag{6}$$

And

$$\frac{\partial (\rho v_y)}{\partial t} + \frac{\partial (y \rho v_x v_y)}{\partial x} + \frac{\partial (y \rho v_y v_y)}{\partial y} + \frac{\partial p}{\partial y} = \frac{\partial}{\partial y} \left[\mu \left(2 \frac{\partial v_y}{\partial y} - \frac{2}{3} \left(\frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y} + \frac{v_y}{y} \right) \right) \right] + \frac{\partial}{\partial x} \left[\mu \left(\frac{\partial v_y}{\partial x} + \frac{\partial v_x}{\partial y} \right) \right] + F_y \tag{7}$$

The combustion modeling played a role in the numerical and simulation work before the experimental work is carried out. One of the main modeling in the combustion process is turbulent combustion modeling. For non-premixed combustion, the concept of Conditional Moment Closure (CMC) was independently proposed by Klimenko (1990) and Bilger (1993). The idea is the changes on using normal conventional averages to the concept of condition the reactive scalars on the mixture fraction. Klimenko has found that turbulent diffusion can be modeled much better in mixture fraction space rather than in physical space. Bilger has derived on the observation that the reactive scalars fluctuation can be associated with the mixture fraction fluctuations. By the year 1999, Klimenko and Bilger (1999) reviewed and did the extension of this concept from non-premixed to premixed turbulent combustion. The Conditional Moment Closure (CMC) equation for species a

$$\frac{\partial Q_\alpha}{\partial t} = -\langle u_i|Z\rangle \frac{\partial Q_\alpha}{\partial x_i} + \langle N|Z\rangle \frac{\partial^2 Q_\alpha}{\partial Z^2} - \frac{1}{\bar{\rho}\tilde{P}(Z)} \frac{\partial}{\partial x_i} [\langle u_i'' y_\alpha''|Z\rangle \bar{\rho}\tilde{P}(Z)] + \langle w_\alpha|Z\rangle \quad (8)$$

2D elliptic CMC equation for species α need to use the cylindrical coordinate for the term $\langle u_i|Z\rangle \frac{\partial Q_\alpha}{\partial x_i}$ since the combustion chamber used is cylindrical in shape. The comparison for the Cartesian (x, y, 0) and cylindrical coordinate (x, r, θ) is as below

$$\frac{\partial \emptyset}{\partial t} + \frac{\partial(\emptyset u)}{\partial x} + \frac{\partial(\emptyset v)}{\partial y} + \frac{\partial(\emptyset w)}{\partial z} = 0 \quad (9)$$

$$\frac{\partial \emptyset}{\partial t} + \frac{\partial(\emptyset u_x)}{\partial x} + \frac{\partial(\emptyset u_r)}{\partial r} + \frac{1}{r}\frac{\partial(\emptyset u_\theta)}{\partial \theta} = 0 \quad (10)$$

where for the cylindrical coordinate, x is for axial, r is for radial and θ is for azimuthal direction. The 2D elliptic CMC equation need axial and radial direction flow and becomes

$$\frac{\partial Q_\alpha}{\partial t} = -\langle u_x|Z\rangle \frac{\partial Q_\alpha}{\partial x} - \langle u_r|Z\rangle \frac{\partial Q_\alpha}{\partial r} + \langle N|Z\rangle \frac{\partial^2 Q_\alpha}{\partial Z^2} + \langle w_\alpha|Z\rangle - \frac{1}{\bar{\rho}\tilde{P}(Z)} \frac{\partial}{\partial x} [\langle u_x'' y_\alpha''|Z\rangle \bar{\rho}\tilde{P}(Z)] - \frac{1}{\bar{\rho}\tilde{P}(Z)} \frac{\partial}{\partial r} [\langle u_r'' y_\alpha''|Z\rangle \bar{\rho}\tilde{P}(Z)] \quad (11)$$

for the term $\langle u_i|Z\rangle \frac{\partial Q_\alpha}{\partial x_i}$ the conditional velocity $\langle u_i|Z\rangle$ which can be considered as "u_i" is a function of "Z". For the term $\frac{1}{\bar{\rho}\tilde{P}(Z)} \frac{\partial}{\partial x_i} [\langle u_i'' y_\alpha''|Z\rangle \bar{\rho}\tilde{P}(Z)]$ the modelling can be done using the Eq. (12) and (13). The conditional turbulent fluxes for any quantity of y_α'', h''or T'' (in general use $\emptyset$) can be modeled with "gradient-diffusion" or "Boussinesq" approximation as below,

$$\rho\langle u'' \emptyset_\alpha''|Z\rangle = -D_t \frac{\partial \emptyset_\alpha}{\partial x} \quad (12)$$

where turbulent diffusivity (D_t) can be calculate by the relation of turbulent viscosity (μ_t) and Schmidt number (Sc_t) as below,

$$D_t = -\frac{\mu_t}{Sc_t} \quad (13)$$

Turbulent viscosity (μ_t) and Schmidt number (Sc_t) are constant. For non-premixed bluff-body flame, Schmidt number used is 1.0 (Giacomazzi et al., 2000, 2004) then the equation is summarised as below. For many cases Schmidt number is varied from 0.45 to 1.0 depending on the flow characteristics. In auto-ignition CMC simulation, Sc_t = 0.9 was used (Wright, 2005). For the axial direction

$$\frac{1}{\bar{\rho}\tilde{P}(Z)} \frac{\partial}{\partial x} [\langle u_i'' y_\alpha''|Z\rangle \bar{\rho}\tilde{P}(Z)] = \frac{1}{\bar{\rho}\tilde{P}(Z)} \frac{\partial}{\partial x} \left[-\frac{\mu_t}{Sc_t} \frac{\partial Q_\alpha}{\partial x} \left(\tilde{P}(Z)\right)\right] \quad (14)$$

$$= -\frac{\mu_t}{\bar{\rho} Sc_t \tilde{P}(Z)} \left[\tilde{P}(Z) \frac{\partial^2 Q_\alpha}{\partial x^2} + \frac{\partial Q_\alpha}{\partial x} \frac{\partial \tilde{P}(Z)}{\partial x}\right] \quad (15)$$

For the radial direction

$$\frac{1}{\bar{\rho}\tilde{P}(Z)}\frac{\partial}{\partial r}[\langle u_i'' y_\alpha''|Z\rangle\bar{\rho}\tilde{P}(Z)] = \frac{1}{\bar{\rho}\tilde{P}(Z)}\frac{\partial}{\partial r}\left[-\frac{\mu_t}{Sc_t}\frac{\partial Q_\alpha}{\partial r}\left(\tilde{P}(Z)\right)\right] \quad (16)$$

$$= -\frac{\mu_t}{\bar{\rho}Sc_t\tilde{P}(Z)}\left[\tilde{P}(Z)\frac{\partial^2 Q_\alpha}{\partial r^2} + \frac{\partial Q_\alpha}{\partial r}\frac{\partial \tilde{P}(Z)}{\partial r}\right] \quad (17)$$

This paper discusses the discretization of the CMC combustion turbulent model using finite difference central method and Taylor expansion series. The discretization for 2D CMC elliptic equation is presented for uniform and non-uniform meshing grids.

TAYLOR EXPANSION

The implicit formulae can be derived from a Taylor series expansion. Implicit finite difference relations have been derived by many mathematicians and physicists with various way and methods (Chapra and Canale, 2006; Adam, 1975; Adam, 1977; Collatz, 1966; Rubin and Graves, 1975; Rubin and Khosla, 1977; Peyret, 1978; Peyret and Taylor, 1982; Krause, 1971; Leventhal, 1980; Hirsh, 1975; Lele, 1992; Ciment, and Leventhal, 975;). Taylor series is a good tool to study and discretized the numerical equation since the theory provides a means to predict a function value at one point in term of the function value and its derivatives at another point. In particular, the theorem states that any smooth function can be approximated as a polynomial (Chapra and Canale, 2006). There are many different types of numerical differentiation formulation, depending on the number of point, direction of the formula and the required derivative order (Griffiths and Smith, 2006). Taylor Expansion is a useful method to reduce the error term. To calculate the value for $\emptyset(x+\Delta x_{+1})$ and $\emptyset(x+\Delta x_{-1})$ until 7th order are as below,

$$\emptyset(x+\Delta x_{+1}) = \emptyset(x) + (\Delta x_{+1})\frac{d\emptyset}{dx}\Big|_{x_0} + \frac{(\Delta x_{+1})^2}{2!}\frac{d^2\emptyset}{dx^2}\Big|_{x_0} + \frac{(\Delta x_{+1})^3}{3!}\frac{d^3\emptyset}{dx^3}\Big|_{x_0} + \frac{(\Delta x_{+1})^4}{4!}\frac{d^4\emptyset}{dx^4}\Big|_{x_0} + \frac{(\Delta x_{+1})^5}{5!}\frac{d^5\emptyset}{dx^5}\Big|_{x_0} + \frac{(\Delta x_{+1})^6}{6!}\frac{d^6\emptyset}{dx^6}\Big|_{x_0} + \frac{(\Delta x_{+1})^7}{7!}\frac{d^7\emptyset}{dx^7}\Big|_{x_0} \quad (18)$$

$$\emptyset(x-\Delta x_{-1}) = \emptyset(x) - (\Delta x_{-1})\frac{d\emptyset}{dx}\Big|_{x_0} + \frac{(\Delta x_{-1})^2}{2!}\frac{d^2\emptyset}{dx^2}\Big|_{x_0} - \frac{(\Delta x_{-1})^3}{3!}\frac{d^3\emptyset}{dx^3}\Big|_{x_0} + \frac{(\Delta x_{-1})^4}{4!}\frac{d^4\emptyset}{dx^4}\Big|_{x_0} - \frac{(\Delta x_{-1})^5}{5!}\frac{d^5\emptyset}{dx^5}\Big|_{x_0} + \frac{(\Delta x_{-1})^6}{6!}\frac{d^6\emptyset}{dx^6}\Big|_{x_0} - \frac{(\Delta x_{-1})^7}{7!}\frac{d^7\emptyset}{dx^7}\Big|_{x_0} \quad (19)$$

CENTRAL DIFFERENCE METHOD FOR UNIFORM GRID

Assuming Δx is constant, $\emptyset(x+\Delta x_{+1})$ will be $\emptyset(x+\Delta x)$ and $\emptyset(x-\Delta x_{-1})$ will be $\emptyset(x-\Delta x)$ as below,

$$\emptyset(x+\Delta x) = \emptyset(x) + \Delta x\frac{d\emptyset}{dx}\Big|_{x_0} + \frac{\Delta x^2}{2}\frac{d^2\emptyset}{dx^2}\Big|_{x_0} + \frac{\Delta x^3}{6}\frac{d^3\emptyset}{dx^3}\Big|_{x_0} + \frac{\Delta x^4}{24}\frac{d^4\emptyset}{dx^4}\Big|_{x_0} + \frac{\Delta x^5}{120}\frac{d^5\emptyset}{dx^5}\Big|_{x_0} + \frac{\Delta x^6}{720}\frac{d^6\emptyset}{dx^6}\Big|_{x_0} + \frac{\Delta x^7}{5040}\frac{d^7\emptyset}{dx^7}\Big|_{x_0} \quad (20)$$

$$\emptyset(x-\Delta x) = \emptyset(x) - \Delta x\frac{d\emptyset}{dx}\Big|_{x_0} + \frac{\Delta x^2}{2}\frac{d^2\emptyset}{dx^2}\Big|_{x_0} - \frac{\Delta x^3}{6}\frac{d^3\emptyset}{dx^3}\Big|_{x_0} + \frac{\Delta x^4}{24}\frac{d^4\emptyset}{dx^4}\Big|_{x_0} - \frac{\Delta x^5}{120}\frac{d^5\emptyset}{dx^5}\Big|_{x_0} + \frac{\Delta x^6}{720}\frac{d^6\emptyset}{dx^6}\Big|_{x_0} - \frac{\Delta x^7}{5040}\frac{d^7\emptyset}{dx^7}\Big|_{x_0} \quad (21)$$

Rearranging both Eq. (20) and (21) will result in the first order derivative equation. This is finite forward difference method which is calculating $\frac{d\emptyset}{dx}$ on the basis of forward movement from $\emptyset(x)$ and $\emptyset(x+\Delta x)$.

$$\frac{d\emptyset}{dx} = \frac{\emptyset(x+\Delta x)-\emptyset(x)}{\Delta x} - \frac{\Delta x}{2}\frac{d^2\emptyset}{dx^2} - \frac{\Delta x^2}{6}\frac{d^3\emptyset}{dx^3} - \frac{\Delta x^3}{24}\frac{d^4\emptyset}{dx^4} - \frac{\Delta x^4}{120}\frac{d^5\emptyset}{dx^5} - \frac{\Delta x^5}{720}\frac{d^6\emptyset}{dx^6} - \frac{\Delta x^6}{5040}\frac{d^7\emptyset}{dx^7} \quad (22)$$

This is finite backward difference method which is calculating $\frac{d\emptyset}{dx}$ based on backward movement from $\emptyset(x)$ and $\emptyset(x-\Delta x)$.

$$\frac{d\emptyset}{dx} = \frac{\emptyset(x)-\emptyset(x-\Delta x)}{\Delta x} + \frac{\Delta x}{2}\frac{d^2\emptyset}{dx^2} - \frac{\Delta x^2}{6}\frac{d^3\emptyset}{dx^3} + \frac{\Delta x^3}{24}\frac{d^4\emptyset}{dx^4} - \frac{\Delta x^4}{120}\frac{d^5\emptyset}{dx^5} + \frac{\Delta x^5}{720}\frac{d^6\emptyset}{dx^6} - \frac{\Delta x^6}{5040}\frac{d^7\emptyset}{dx^7} \quad (23)$$

This is finite central difference method which is calculating $\frac{d\emptyset}{dx}$ base on central movement from $\emptyset(x-\Delta x)$ and $\emptyset(x+\Delta x)$ obtained from the difference between 20 and 21.

$$\frac{d\emptyset}{dx} = \frac{\emptyset(x+\Delta x)-\emptyset(x-\Delta x)}{2\Delta x} - \frac{\Delta x^2}{6}\frac{d^3\emptyset}{dx^3} - \frac{\Delta x^4}{120}\frac{d^5\emptyset}{dx^5} - \frac{\Delta x^6}{5040}\frac{d^7\emptyset}{dx^7} \quad (24)$$

with leading error term of $O(\Delta x^2)$. Higher order finite difference method is necessary to ensure the simulations is more accurate and more error term is cancelled off by higher derivative. Using central different derivative, the addition of Eq. (20) and (21), can summarized as

$$\frac{d^2\emptyset}{dx^2} = \frac{\emptyset(x+\Delta x)-2\emptyset(x)+\emptyset(x-\Delta x)}{\Delta x^2} - \frac{\Delta x^2}{12}\frac{d^4\emptyset}{dx^4} - \frac{\Delta x^4}{360}\frac{d^6\emptyset}{dx^6} \quad (25)$$

with leading error term of $O(\Delta x^2)$. First order derivative for fifth order Taylor expansion scheme are summarized as below, for the derivative between $\emptyset(x+2\Delta x)$ to $\emptyset(x-2\Delta x)$

$$\frac{d\emptyset}{dx} = \frac{\emptyset(x-2\Delta x)-8\emptyset(x-\Delta x)+8\emptyset(x+\Delta x)-\emptyset(x-2\Delta x)}{12\Delta x} + \frac{\Delta x^4}{30}\frac{d^5\emptyset}{dx^5} \quad (26)$$

with leading error term of $O(\Delta x^4)$. Second order derivative for fifth order Taylor expansion scheme are summarized as below, for the derivative between $\emptyset(x+3\Delta x)$ to $\emptyset(x-3\Delta x)$:

$$\frac{d^2\emptyset}{dx^2} = \frac{-\emptyset(x-2\Delta x)+16\emptyset(x-\Delta x)-30\emptyset(x)+16\emptyset(x+\Delta x)-\emptyset(x+2\Delta x)}{12\Delta x^2} + \frac{\Delta x^4}{90}\frac{d^6\emptyset}{dx^6} \quad (27)$$

with leading error term of $O(\Delta x^4)$. Third order derivative for fifth order Taylor expansion scheme are summarized as below, for the derivative between $\emptyset(x+3\Delta x)$ to $\emptyset(x-3\Delta x)$:

$$\frac{d^3\emptyset}{dx^3} = \frac{-\emptyset(x-2\Delta x)+2\emptyset(x-\Delta x)-2\emptyset(x+\Delta x)+\emptyset(x+2\Delta x)}{2\Delta x^2} - \frac{\Delta x^2}{4}\frac{d^5\emptyset}{dx^5} \quad (28)$$

with leading error term of $O(\Delta x^2)$. Assuming that there is a uniform spacing of Δx, using notation that is $\emptyset^k = \frac{d^k y}{dx^k}$, for the Taylor series expansion, central difference derivatives can be summarized as Eq. (29):

$$\emptyset^k = \sum_{i=-\frac{(n-1)}{2}}^{\frac{(n-1)}{2}} z_i \emptyset_i + ET \tag{29}$$

Forward difference derivatives can be summarized as:

$$\emptyset^k = \sum_{i=0}^{n-1} z_i \emptyset_i + ET \tag{30}$$

Backward difference derivatives can be summarized as:

$$\emptyset^k = \sum_{i=-(n-1)}^{0} z_i \emptyset_i + ET \tag{31}$$

where n is the number of points ($\emptyset_{-2}, \emptyset_{-1,} \emptyset_0, \emptyset_{1,} \emptyset_2$ is equal to five points), ET is the leading error term and z_i is the coefficient of $\emptyset$ for each point i.

CENTRAL DIFFERENCE METHOD FOR NON-UNIFORM GRID

Equation (18) multiply by $(\Delta x_{-1})^2$ and Eq. (19) multiply by $(\Delta x_{+1})^2$

$$\emptyset(x+\Delta x_{+1})(\Delta x_{-1})^2 = \emptyset(x)(\Delta x_{-1})^2 + (\Delta x_{+1})(\Delta x_{-1})^2 \frac{d\emptyset}{dx}\Big|_{x_0} + \frac{(\Delta x_{+1})^2(\Delta x_{-1})^2}{2!}\frac{d^2\emptyset}{dx^2}\Big|_{x_0} + \frac{(\Delta x_{+1})^3(\Delta x_{-1})^2}{3!}\frac{d^3\emptyset}{dx^3}\Big|_{x_0} + \frac{(\Delta x_{+1})^4(\Delta x_{-1})^2}{4!}\frac{d^4\emptyset}{dx^4}\Big|_{x_0} + \frac{(\Delta x_{+1})^5(\Delta x_{-1})^2}{5!}\frac{d^5\emptyset}{dx^5}\Big|_{x_0} + \frac{(\Delta x_{+1})^6(\Delta x_{-1})^2}{6!}\frac{d^6\emptyset}{dx^6}\Big|_{x_0} + \frac{(\Delta x_{+1})^7(\Delta x_{-1})^2}{7!}\frac{d^7\emptyset}{dx^7}\Big|_{x_0} \tag{32}$$

$$\emptyset(x-\Delta x_{-1})(\Delta x_{+1})^2 = \emptyset(x)(\Delta x_{+1})^2 - (\Delta x_{-1})(\Delta x_{+1})^2 \frac{d\emptyset}{dx}\Big|_{x_0} + \frac{(\Delta x_{-1})^2(\Delta x_{+1})^2}{2!}\frac{d^2\emptyset}{dx^2}\Big|_{x_0} - \frac{(\Delta x_{-1})^3(\Delta x_{+1})^2}{3!}\frac{d^3\emptyset}{dx^3}\Big|_{x_0} + \frac{(\Delta x_{-1})^4(\Delta x_{+1})^2}{4!}\frac{d^4\emptyset}{dx^4}\Big|_{x_0} - \frac{(\Delta x_{-1})^5(\Delta x_{+1})^2}{5!}\frac{d^5\emptyset}{dx^5}\Big|_{x_0} + \frac{(\Delta x_{-1})^6(\Delta x_{+1})^2}{6!}\frac{d^6\emptyset}{dx^6}\Big|_{x_0} - \frac{(\Delta x_{-1})^7(\Delta x_{+1})^2}{7!}\frac{d^7\emptyset}{dx^7}\Big|_{x_0} \tag{33}$$

Take the difference between Eq. (32) and (33), The $\frac{d\emptyset}{dx}$ is

$$\emptyset(x+\Delta x_{+1})(\Delta x_{-1})^2 - \emptyset(x-\Delta x_{-1})(\Delta x_{+1})^2 = \emptyset(x)(\Delta x_{-1})^2 - \emptyset(x)(\Delta x_{+1})^2 + (\Delta x_{+1})(\Delta x_{-1})^2 \frac{d\emptyset}{dx}\Big|_{x_0} + (\Delta x_{-1})(\Delta x_{+1})^2 \frac{d\emptyset}{dx}\Big|_{x_0} + \frac{(\Delta x_{+1})^3(\Delta x_{-1})^2}{3!}\frac{d^3\emptyset}{dx^3}\Big|_{x_0} + \frac{(\Delta x_{-1})^3(\Delta x_{+1})^2}{3!}\frac{d^3\emptyset}{dx^3}\Big|_{x_0} + \frac{(\Delta x_{+1})^4(\Delta x_{-1})^2}{4!}\frac{d^4\emptyset}{dx^4}\Big|_{x_0} + \frac{(\Delta x_{-1})^4(\Delta x_{+1})^2}{4!}\frac{d^4\emptyset}{dx^4}\Big|_{x_0} + \frac{(\Delta x_{+1})^5(\Delta x_{-1})^2}{5!}\frac{d^5\emptyset}{dx^5}\Big|_{x_0} + \frac{(\Delta x_{-1})^5(\Delta x_{+1})^2}{5!}\frac{d^5\emptyset}{dx^5}\Big|_{x_0} + \frac{(\Delta x_{+1})^6(\Delta x_{-1})^2}{6!}\frac{d^6\emptyset}{dx^6}\Big|_{x_0} + \frac{(\Delta x_{-1})^6(\Delta x_{+1})^2}{6!}\frac{d^6\emptyset}{dx^6}\Big|_{x_0} + \frac{(\Delta x_{+1})^7(\Delta x_{-1})^2}{7!}\frac{d^7\emptyset}{dx^7}\Big|_{x_0} + \frac{(\Delta x_{-1})^7(\Delta x_{+1})^2}{7!}\frac{d^7\emptyset}{dx^7}\Big|_{x_0} \tag{34}$$

The error becomes smaller and the equation will be truncated with leading error term of $O(\Delta x^2)$

$$\emptyset(x+\Delta x_{+1})(\Delta x_{-1})^2-\emptyset(x-\Delta x_{-1})(\Delta x_{+1})^2=\emptyset(x)(\Delta x_{-1})^2-\emptyset(x)(\Delta x_{+1})^2+(\Delta x_{+1})(\Delta x_{-1})^2\frac{d\emptyset}{dx}+(\Delta x_{-1})(\Delta x_{+1})^2\frac{d\emptyset}{dx}+\frac{(\Delta x_{+1})^3(\Delta x_{-1})^2}{3!}\frac{d^3\emptyset}{dx^3}+\frac{(\Delta x_{-1})^3(\Delta x_{+1})^2}{3!}\frac{d^3\emptyset}{dx^3} \quad (35)$$

$$[(\Delta x_{+1})(\Delta x_{-1})^2+(\Delta x_{-1})(\Delta x_{+1})^2]\frac{d\emptyset}{dx}=\emptyset(x+\Delta x_{+1})(\Delta x_{-1})^2-\emptyset(x-\Delta x_{-1})(\Delta x_{+1})^2-\emptyset(x)[(\Delta x_{-1})^2-(\Delta x_{+1})^2]+\frac{1}{6}[(\Delta x_{+1})^3(\Delta x_{-1})^2+(\Delta x_{-1})^3(\Delta x_{+1})^2]\frac{d^3\emptyset}{dx^3} \quad (36)$$

$$\frac{d\emptyset}{dx}=\frac{\emptyset(x+\Delta x_{+1})(\Delta x_{-1})^2-\emptyset(x)\left[(\Delta x_{-1})^2-\Delta x_{+1}{}^2\right]-\emptyset(x-\Delta x_{-1})(\Delta x+10)^2}{(\Delta x_{+1})(\Delta x_{-1})[(\Delta x_{-1})+(\Delta x_{+1})\}}+\frac{1}{6}\frac{[(\Delta x_{+1})^3(\Delta x_{-1})^2+(\Delta x_{-1})^3(\Delta x_{+1})^2]}{(\Delta x_{-1})(\Delta x_{-1})[(\Delta x_{-1})(\Delta x_{-1})]}\frac{d^3\emptyset}{dx^3} \quad (37)$$

Then for three dimensional elliptic equations, first derivative is

$$\frac{d\emptyset}{dx}=\frac{\emptyset(x+\Delta x_{+1},y,z)(\Delta x_{-1})^2-\emptyset(x,y,z)\left[(\Delta x_{-1})^2-(\Delta x_{+1})^2\right]-\emptyset(x-\Delta x_{-1},y,z)(\Delta x_{+1})^2}{(\Delta x_{+1})(\Delta x_{-1})[(\Delta x_{-1})+(\Delta x_{+1})]} \quad (38)$$

$$\frac{d\emptyset}{dy}=\frac{\emptyset(x,y+\Delta y_{+1},z)(\Delta y_{-1})^2-\emptyset(x,y,z)\left[(\Delta y_{-1})^2-(\Delta y_{+1})^2\right]-\emptyset(x,y-\Delta y_{-1},z)(\Delta y_{+1})^2}{(\Delta y_{+1})(\Delta y_{-1})[(\Delta y_{-1})+(\Delta y_{+1})]} \quad (39)$$

$$\frac{d\emptyset}{dz}=\frac{\emptyset(x,y,z+\Delta z_{+1})(\Delta z_{-1})^2-\emptyset(x,y,z)\left[(\Delta z_{-1})^2-(\Delta z_{+1})^2\right]-\emptyset(x,y,z-\Delta z_{-1})(\Delta z_{+1})^2}{(\Delta z_{+1})(\Delta z_{-1})[(\Delta z_{-1})+(\Delta z_{+1})]} \quad (40)$$

For the term $\frac{d^2\emptyset}{dx^2}$, the term must $\frac{d\emptyset}{dx}$ be cancel off. Equation (18) multiply by Δx_{-1} and Eq. (19) multiply by Δx_{+1}

$$\emptyset(x+\Delta x_{+1})(\Delta x_{-1})=\emptyset(x)(\Delta x_{-1})+(\Delta x_{+1})(\Delta x_{-1})\frac{d\emptyset}{dx}\Big|_{x_0}+\frac{(\Delta x_{+1})^2(\Delta x_{-1})}{2!}\frac{d^2\emptyset}{dx^2}\Big|_{x_0}+\frac{(\Delta x_{+1})^3(\Delta x_{-1})}{3!}\frac{d^3\emptyset}{dx^3}\Big|_{x_0}+\frac{(\Delta x_{+1})^4(\Delta x_{-1})}{4!}\frac{d^4\emptyset}{dx^4}\Big|_{x_0}+\frac{(\Delta x_{+1})^5(\Delta x_{-1})}{5!}\frac{d^5\emptyset}{dx^5}\Big|_{x_0}+\frac{(\Delta x_{+1})^6(\Delta x_{-1})}{6!}\frac{d^6\emptyset}{dx^6}\Big|_{x_0}+\frac{(\Delta x_{+1})^7(\Delta x_{-1})}{7!}\frac{d^7\emptyset}{dx^7}\Big|_{x_0} \quad (41)$$

$$\emptyset(x-\Delta x_{-1})(\Delta x_{+1})=\emptyset(x)(\Delta x_{+1})-(\Delta x_{-1})(\Delta x_{+1})\frac{d\emptyset}{dx}\Big|_{x_0}+\frac{(\Delta x_{-1})^2(\Delta x_{+1})}{2!}\frac{d^2\emptyset}{dx^2}\Big|_{x_0}-\frac{(\Delta x_{-1})^3(\Delta x_{+1})}{3!}\frac{d^3\emptyset}{dx^3}\Big|_{x_0}+\frac{(\Delta x_{-1})^4(\Delta x_{+1})}{4!}\frac{d^4\emptyset}{dx^4}\Big|_{x_0}-\frac{(\Delta x_{-1})^5(\Delta x_{+1})}{5!}\frac{d^5\emptyset}{dx^5}\Big|_{x_0}+\frac{(\Delta x_{-1})^6(\Delta x_{+1})}{6!}\frac{d^6\emptyset}{dx^6}\Big|_{x_0}-\frac{(\Delta x_{-1})^7(\Delta x_{+1})}{7!}\frac{d^7\emptyset}{dx^7}\Big|_{x_0} \quad (42)$$

Take the summation of the Eq. (41) and (42), Then $\frac{d^2\emptyset}{dx^2}$ is

$$\emptyset(x+\Delta x_{+1})(\Delta x_{-1})+\emptyset(x-\Delta x_{-1})(\Delta x_{+1})=\emptyset(x)(\Delta x_{-1})+\emptyset(x)(\Delta x_{+1})+\frac{(\Delta x_{+1})^2(\Delta x_{-1})}{2!}\frac{d^2\emptyset}{dx^2}\Big|_{x_0}+\frac{(\Delta x_{-1})^2(\Delta x_{+1})}{2!}\frac{d^2\emptyset}{dx^2}\Big|_{x_0}+\frac{(\Delta x_{+1})^3(\Delta x_{-1})}{3!}\frac{d^3\emptyset}{dx^3}\Big|_{x_0}-\frac{(\Delta x_{-1})^3(\Delta x_{+1})}{3!}\frac{d^3\emptyset}{dx^3}\Big|_{x_0}+\frac{(\Delta x_{+1})^4(\Delta x_{-1})}{4!}\frac{d^4\emptyset}{dx^4}\Big|_{x_0}+\frac{(\Delta x_{-1})^4(\Delta x_{+1})}{4!}\frac{d^4\emptyset}{dx^4}\Big|_{x_0}+\frac{(\Delta x_{+1})^5(\Delta x_{-1})}{5!}\frac{d^5\emptyset}{dx^5}\Big|_{x_0}-\frac{(\Delta x_{-1})^5(\Delta x_{+1})}{5!}\frac{d^5\emptyset}{dx^5}\Big|_{x_0}+$$

$$\frac{(\Delta x_{+1})^6(\Delta x_{-1})}{6!}\frac{d^6\emptyset}{dx^6}\Big|_{x_0} + \frac{(\Delta x_{-1})^6(\Delta x_{+1})}{6!}\frac{d^6\emptyset}{dx^6}\Big|_{x_0} + \frac{(\Delta x_{+1})^7(\Delta x_{-1})}{7!}\frac{d^7\emptyset}{dx^7}\Big|_{x_0} - \frac{(\Delta x_{-1})^7(\Delta x_{+1})}{7!}\frac{d^7\emptyset}{dx^7}\Big|_{x_0} \quad (43)$$

The error becomes smaller and the equation will be truncated with leading error term of $O(\Delta x^2)$

$$\emptyset(x+\Delta x_{+1})(\Delta x_{-1}) + \emptyset(x-\Delta x_{-1})(\Delta x_{+1}) = \emptyset(x)(\Delta x_{-1}) + \emptyset(x)(\Delta x_{+1}) + \frac{(\Delta x_{+1})^2(\Delta x_{-1})}{2!}\frac{d^2\emptyset}{dx^2} + \frac{(\Delta x_{-1})^2(\Delta x_{+1})}{2!}\frac{d^2\emptyset}{dx^2} + \frac{(\Delta x_{+1})^3(\Delta x_{-1})}{3!}\frac{d^3\emptyset}{dx^3} - \frac{(\Delta x_{-1})^3(\Delta x_{+1})}{3!}\frac{d^3\emptyset}{dx^3} \quad (44)$$

$$\frac{1}{2}[(\Delta x_{+1})^2(\Delta x_{-1})^2 + (\Delta x_{-1})^2(\Delta x_{+1})^2]\frac{d^2\emptyset}{dx^2} = \emptyset(x+\Delta x_{+1})(\Delta x_{-1}) - \emptyset(x)[(\Delta x_{-1})(\Delta x_{+1})] + \emptyset(x-\Delta x_{-1})(\Delta x_{+1}) + \frac{1}{6}[(\Delta x_{+1})^3(\Delta x_{-1})^2 - (\Delta x_{-1})^3(\Delta x_{+1})]^2\frac{d^3\emptyset}{dx^3} \quad (45)$$

$$\frac{d^2\emptyset}{dx^2} = 2\frac{\emptyset(x+\Delta x_{+1})(\Delta x_{-1}) - \emptyset(x)[(\Delta x_{-1})(\Delta x_{+1})] + \emptyset(x-\Delta x_{-1})(\Delta x_{+1})}{(\Delta x_{+1})(\Delta x_{-1})[(\Delta x_{+1}\Delta x_{-1}])} + \frac{1}{6}\frac{[(\Delta x_{+1})^3(\Delta x_{-1})^2(\Delta x_{-1})^3(\Delta x_{+1})]^2}{(\Delta x_{+1})(\Delta x_{-1})[(\Delta x_{+1}\Delta x_{-1}])}\frac{d^3\emptyset}{dx^3} \quad (46)$$

The term of $O(\Delta x^2)$ can be truncated and becomes the error term. Then for three dimensional equation, second derivative is

$$\frac{d^2\emptyset}{dx^2} = 2\frac{\emptyset(x+\Delta x_{+1},y,z)(\Delta x_{-1}) - \emptyset(x,y,z)[(\Delta x_{-1})+(\Delta x_{+1})] + \emptyset(x-\Delta x_{-1},y,z)(\Delta x_{+1})}{(\Delta x_{+1})(\Delta x_{-1})[(\Delta x_{+1})+(\Delta x_{-1})]} \quad (47)$$

$$\frac{d^2\emptyset}{dy^2} = 2\frac{\emptyset(x,y+\Delta y_{+1},z)(\Delta y_{-1}) - \emptyset(x,y,z)[(\Delta y_{-1})+(\Delta y_{+1})] + \emptyset(x,y-\Delta y_{-1},z)(\Delta y_{+1})}{(\Delta y_{+1})(\Delta y_{-1})[(\Delta y_{+1})+(\Delta y_{-1})]} \quad (48)$$

$$\frac{d^2\emptyset}{dz^2} = 2\frac{\emptyset(x,y,z+\Delta z_{+1})(\Delta z_{-1}) - \emptyset(x,y,z)[(\Delta z_{-1})+(\Delta z_{+1})] + \emptyset(x,y,z-\Delta z_{-1})(\Delta z_{+1})}{(\Delta z_{+1})(\Delta z_{-1})[(\Delta z_{+1})+(\Delta z_{-1})]} \quad (49)$$

NUMERICAL METHOD: FINITE DIFFERENCE METHOD

When the complex engineering problem comes with many dimensions and parameters, the same non-linear partial differential equations (PDEs) are used for all the problems. Solving these types of problems using analytical solutions is extremely difficult and in most cases do not have analytical solutions. Then, to solve this type of problem, numerical solution has been developed, such as finite difference method (FDM), finite element method (FEM) and finite volume method (FVM) (Fletcher, 1991; Hoftman et al., 2000, 2001; Slingerland and Kump, 2011). The FDM is a numerical method for approximating the solutions to partial differential equations by using finite difference equations. FDM uses approximate derivatives based on the properties of Taylor expansions and on the straight forward application of the definition of derivatives (Hirsh, 2007). The objective is to transform the equation from continuous form. The steps are discretizing the continuous physical domain to discrete finite different grid and then approximate the individual partial derivative in the partial differential equation. Using Taylor expansion method, partial differential equation was discretized in order to transform it to FORTRAN code.

Homogeneous CMC

The Homogenous CMC equation is

$$\frac{\partial\langle Y|Z\rangle}{\partial t} = \langle N|Z\rangle\frac{\partial^2\langle Y|Z\rangle}{\partial Z^2} + \langle W|Z\rangle + \langle S|Z\rangle \tag{50}$$

For a passive, conserved scalar CMC equation:

$$\frac{\partial\langle Y|Z\rangle}{\partial t} = \langle N|Z\rangle\frac{\partial^2\langle Y|Z\rangle}{\partial Z^2} \tag{51}$$

From the equation, the conditional mass fraction term $\langle Y|Z\rangle$ is mathematically written as Y to the function of Z (written as Y(Z)) and conditional scalar dissipation $\langle N|Z\rangle$ is written as N to the function of Z (written as N(Z)). Then CMC equation becomes:

$$\frac{d\emptyset}{dt} = N\frac{d^2\emptyset}{dz^2} \tag{52}$$

From Taylor expansion, equation can be summarized as

$$\frac{d\emptyset}{dt} = \frac{\emptyset(z,t+\Delta t)-\emptyset(z,t)}{(\Delta t)} \tag{53}$$

$$\frac{d^2\emptyset}{dz^2} = \frac{\emptyset(z+\Delta z,t)-2\emptyset(z,t)+\emptyset(z-\Delta z,t)}{(\Delta z)^2} \tag{54}$$

The final form of CMC equation after discretize is as

$$\emptyset(i,j+1) = (1-(2*B))*\emptyset(i,j) + B*\emptyset(i+1,j) + B*\emptyset(i-1,j) \tag{55}$$

where B = $N\frac{\Delta t}{(\Delta z)^2}$. Equation (55) was coded in FORTRAN or MATLAB to simulate the CMC modelling (Noor et al., 2012). The parameter for the code:
dt = changing in time
dz = changing in space
TT = total time for the simulation

Two Dimensional CMC

For 2D modeling, the CMC equation

$$\frac{\partial Q_\alpha}{\partial t} = -\langle u_x|Z\rangle\frac{\partial Q_\alpha}{\partial x} + \langle u_r|Z\rangle\frac{\partial Q_\alpha}{\partial r} + \langle N|Z\rangle\frac{\partial^2 Q_\alpha}{\partial Z^2} + \langle w_\alpha|Z\rangle - \frac{1}{\bar{\rho}\tilde{P}(Z)}\frac{\partial}{\partial x}[\langle u_x'' y_\alpha''|Z\rangle\bar{\rho}\tilde{P}(Z)] - \frac{1}{\bar{\rho}\tilde{P}(Z)}\frac{\partial}{\partial x}[\langle u_r'' y_\alpha''|Z\rangle\bar{\rho}\tilde{P}(Z)] \tag{56}$$

Discretization term by term

$$\frac{d\emptyset}{dt} = \frac{\emptyset_{i,j,k}^{p+1}-\emptyset_{i,j,k}^{p}}{\Delta t} \tag{57}$$

Where superscript *p* represents time, subscript *i* and *j* represent the coordinate system for the numerical space and *k* represents the mixture fraction. For non-uniform grid, Δx is not uniform

$$u\frac{d\emptyset}{dx} = \begin{cases} 1{:}\frac{u}{\Delta x^{-}_{i,j,k}}\left(\emptyset^{p}_{i,j,k} - \emptyset^{p}_{i-1,j,k}\right) for\ u\ \geq 0 \\ 1{:}\frac{u}{\Delta x^{+}_{i,j,k}}\left(\emptyset^{p}_{i+1,j,k} - \emptyset^{p}_{i,j,k}\right) for\ u\ < 0 \end{cases} \tag{58}$$

where $\Delta x^{-}_{i,j,k} = x_{i,j,k} - x_{i-1,j,k}\ and\ \Delta x^{+}_{i,j,k} = x_{i+1,j,k} - x_{i,j,k}$. For the radial direction

$$u\frac{d\emptyset}{dr} = \begin{cases} 1{:}\frac{u}{\Delta r^{-}_{i,j,k}}\left(\emptyset^{p}_{i,j,k} - \emptyset^{p}_{i,j-1,k}\right) for\ u\ \geq 0 \\ 1{:}\frac{u}{\Delta r^{+}_{i,j,k}}\left(\emptyset^{p}_{i,j+1,k} - \emptyset^{p}_{i,j,k}\right) for\ u\ < 0 \end{cases} \tag{59}$$

where $\Delta r^{-}_{i,j,k} = r_{i,j,k} - r_{i,j-1,k}$ and $\Delta r^{+}_{i,j,k} = r_{i,j+1,k} - r_{i,j,k}$. For the $N\frac{\partial^2\emptyset}{dZ^2}$ the discretization is

$$N\frac{\partial^2\emptyset}{dZ^2} = \frac{N}{\Delta Z^2}\left(\emptyset^{p}_{i,j,k+1} - 2\emptyset^{p}_{i,j,k} + \emptyset^{p}_{i,j,k-1}\right) \tag{60}$$

For three dimensional elliptic equation, from Eq. (38) and (40), the first derivative is

$$\frac{\partial\emptyset}{\partial x} = \frac{\emptyset(x+\Delta x_{+1},y,z)(\Delta x_{-1})^2 - \emptyset(x,y,z)\left[(\Delta x_{-1})^2 - (\Delta x_{+1})^2\right] - \emptyset(x-\Delta x_{-1},y,z)(\Delta x_{+1})^2}{(\Delta x_{+1})(\Delta x_{-1})[(\Delta x_{+1}) + (\Delta x_{-1})]} \tag{61}$$

$$= \frac{\emptyset^{p}_{i+1,j,k}(\Delta x_{i-1})^2 - \emptyset^{p}_{i,j,k}\left[(\Delta x_{i-1})^2 - (\Delta x_{i+1})^2\right] - \emptyset^{p}_{i-1,j,k}(\Delta x_{i+1})^2}{(\Delta x_{i+1})(\Delta x_{i-1})[(\Delta x_{i+1}) + (\Delta x_{i-1})]} \tag{62}$$

$$\frac{\partial\emptyset}{\partial y} = \frac{\emptyset(x,y+\Delta y_{+1},z)(\Delta y_{-1})^2 - \emptyset(x,y,z)\left[(\Delta y_{-1})^2 + (\Delta y_{+1})^2\right] - \emptyset(x,y-\Delta y_{-1}z)(\Delta y_{+1})^2}{(\Delta y_{+1})(\Delta y_{-1})[(\Delta y_{+1}) + (\Delta y_{-1})]} \tag{63}$$

$$= \frac{\emptyset^{p}_{i,j+1,k}\left(\Delta y_{j-1}\right)^2 - \emptyset^{p}_{i,j,k}\left[\left(\Delta y_{j-1}\right)^2 - \left(\Delta y_{j+1}\right)^2\right] - \emptyset^{p}_{i,j-1,k}\left(\Delta y_{j+1}\right)^2}{(\Delta y_{j+1})(\Delta y_{j-1})[(\Delta y_{j+1}) + (\Delta y_{j-1})]} \tag{64}$$

$$\frac{\partial\emptyset}{\partial z} = \frac{\emptyset(x,y,z+\Delta z_{+1})(\Delta z_{-1})^2 - \emptyset\left[(x,y,z)(\Delta z_{-1})^2 - (\Delta z_{+1})^2\right] - \emptyset(x,y,z-\Delta z_{-1})(\Delta z_{+1})^2}{(\Delta z_{+1})(\Delta z_{-1})[(\Delta z_{+1}) + (\Delta z_{-1})]} \tag{65}$$

$$= \frac{\emptyset^{p}_{i,j,k+1}(\Delta x_{k-1})^2 - \emptyset^{p}_{i,j,k}\left[(\Delta z_{k-1})^2 - (\Delta z_{k+1})^2\right] - \emptyset^{p}_{i,j,k-1}(\Delta z_{k+1})^2}{(\Delta z_{k+1})(\Delta z_{k-1})[(\Delta z_{k+1}) + (\Delta z_{k-1})]} \tag{66}$$

For two dimensional elliptic equation, the cylindrical equation needs to be used since the combustion chamber is in the cylindrical shape. From Eq. (38) and (39), the first derivative is

$$\frac{\partial\emptyset}{\partial x} = \frac{\emptyset(x+\Delta x_{+1},r,\theta)(\Delta x_{-1})^2 - \emptyset(x,r,\theta)[(\Delta x_{-1})^2 - (\Delta x_{+1})^2 - \emptyset(x-\Delta x_{-1},r,\theta)(\Delta x_{+1})^2}{(\Delta x_{+1})(\Delta x_{-1})[(\Delta x_{+1}) + (\Delta x_{-1})]} \tag{67}$$

$$= \frac{\emptyset^{p}_{i+1,j,k}(\Delta x_{i-1})^2 - \emptyset^{p}_{i,j,k}[(\Delta x_{i-1})^2 - (\Delta x_{i+1})^2 - \emptyset^{p}_{i-1,j,k}(\Delta x_{i+1})^2]}{(\Delta x_{i+1})(\Delta x_{i-1})[(\Delta x_{i+1}) + (\Delta x_{i-1})]} \tag{68}$$

$$\frac{\partial\emptyset}{\partial r} = \frac{\emptyset(x,r+\Delta r_{+1},\theta)(\Delta r_{+1})^2 - \emptyset(x,r,\theta)[(\Delta r_{-1})^2 - (\Delta r_{+1})^2 - \emptyset(x,r-\Delta r_{-1},\theta)(\Delta r_{+1})^2}{(\Delta r_{+1})(\Delta r_{-1})[(\Delta r_{+1}) + (\Delta r_{-1})]} \tag{69}$$

$$= \frac{\emptyset^{p}_{i,j+1,k}(\Delta r_{j-1})^2 - \emptyset^{p}_{i,j,k}[\left(\Delta r_{j-1}\right)^2 - \left(\Delta r_{j+1}\right)^2 - \emptyset^{p}_{i,j-1,k}(\Delta r_{j+1})^2]}{(\Delta r_{j+1})(\Delta r_{j-1})[(\Delta r_{j+1}) + (\Delta r_{j-1})]} \tag{70}$$

For 2D elliptic equation, from Eq. (47) and (49), the second derivative is:

$$\frac{d^2\emptyset}{dx^2} = 2\frac{\emptyset\left(x+\Delta x_{+1},r,\theta\right)(\Delta x_{-1})-\emptyset[(x,r,\theta)(\Delta x_{-1})-(\Delta x_{+1})]-\emptyset\left(x-\Delta x_{-1},r,\theta\right)(\Delta x_{+1})}{(\Delta x_{+1})(\Delta x_{-1})[(\Delta x_{+1})+(\Delta x_{-1})]} \quad (71)$$

$$= 2\frac{\emptyset^p_{i+1,j,k}(\Delta x_{i-1})-\emptyset^p_{i,j,k}[\Delta x_{i-1}-\Delta x_{i+1}]-\emptyset^p_{i-1,j,k}(\Delta x_{i+1})}{(\Delta x_{i+1})(\Delta x_{i-1})[(\Delta x_{i+1})+(\Delta x_{i-1})]} \quad (72)$$

$$\frac{d^2\emptyset}{dr^2} = 2\frac{\emptyset(x,r+\Delta r_{+1},\theta)(\Delta r_{-1})-\emptyset(x,r,\theta)[(\Delta r_{-1})-(\Delta r_{+1})]+\emptyset(x,r-\Delta r_{-1},\theta)(\Delta r_{+1})}{(\Delta r_{+1})(\Delta r_{-1})[(\Delta r_{+1})+(\Delta r_{-1})]} \quad (73)$$

$$= 2\frac{\emptyset^p_{i,j+1,k}(\Delta r_{j-1})-\emptyset^p_{i,j,k}[\Delta z_{j-1}-\Delta x_{j+1}]+\emptyset^p_{i,j-1,k}\Delta r_{j+1}}{(\Delta r_{j+1})(\Delta r_{j-1})[(\Delta r_{j+1})+(\Delta r_{j-1})]} \quad (74)$$

Two dimensional CMC Eq. (56) can be discretised using Eq. (57), (58), (59), (60), (68, (70), (72) and (74).

CONCLUSIONS

The CMC equation was discretized in order to transform the calculus partial differential equation to algebra discrete equation. The discretization process of elliptic CMC equation was using Taylor expansion. For the small and simple fluid flow problem, uniform grid can be used, but turbulent combustion modeling, which is a very complex process, requiring the application of non-uniform grid meshing. The term by term discretization can be coded into FORTRAN or MATLAB software in order to solve the turbulent combustion modeling using CMC turbulence model.

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NOMENCLATURE

CMC Conditional Moment Closure
c_p specific heat, J/kgK
D diffusivity

g gravitational acceleration, m/s^2
k thermal conductivity, W/mK
N scalar dissipation rate
P gas pressure
P, PDF Probability Density Function
T temperature, K
u velocity, m/s
V volume, m^3
W chemical source term
w molecular weight of a gas mixture
Z mixture fraction (a conserved scalar)
α thermal diffusivity, m^2/s
μ dynamic viscosity, Pa.s, Ns/m
ν kinematic viscosity, m^2/s
ρ density or concentration of a gas, kg/m^3
$\langle \ | \ \rangle$ conditional average
$\langle N|Z \rangle$ conditional scalar dissipation
$\langle S|Z \rangle$ conditional generation due to droplet evaporation
$\langle W|Z \rangle$ conditional chemical source term
$\langle Y|Z \rangle$ mass fraction of fuel

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THE AIR FUEL RATIO STUDY FOR THE MIXTURE OF BIOGAS AND HYDROGEN ON MILD COMBUSTION

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ABSTRACT

Air Fuel Ratio (AFR) is an important parameter to indicate the combustion quality. Lower AFR will result in Unburned Hydrocarbons (UHC) that harms the environment. This paper discusses the simulation of AFR for the Moderate or Intense Low oxygen Dilution (MILD) combustion using bluff-body burner. A low calorie biogas fuel of 50% methane, 20% hydrogen and 30% carbon dioxide were used in this simulation. The AFR will be evaluated based on the UHC produced and measured in the exhaust gas composition. Stoichiometric AFR produced zero UHC and zero excess Oxygen measured in the exhaust gas. UHC in the exhaust gas is a waste of fuel and is possible to create unwanted combustion at unwanted location. The study found that at AFR 4:1, almost zero UHC was detected in the exhaust gas pipe and Exhaust Gas Recirculation (EGR) pipe.

Keywords: air fuel ratio; MILD combustion; biogas; hydrogen; exhaust gas recirculation.

INTRODUCTION

Fuel cost for heating process is accounted up to 10 ~ 15% from total production cost (USDOE, 2001). Both fuel efficiency and lean combustion are very critical to reduce the total production cost and directly reduce the end product cost. Demand for clean and low cost energy is become a global issue due to the depletion of fossil fuel and environmental pollution concern (Shafie and Topal, 2009). A high thermal efficiency combustion technology and biogas fuel are produced from local feedstock are possible long term solutions. MILD combustion is one of the new combustion technologies to increase thermal efficiency and reduce combustion pollution emission (Cavaliere and Joannon, 2004; Dally et al., 2004, 2010). This technology is also known as Flameless Oxidation (FLOX) (Wünning, 1991, 1996). The MILD combustion is getting more attention from the scientific community (Joannon et al., 2000) and labeled as part of the dilution combustion technology (Torresi et al., 2010). It emits low nitrogen oxides (NO_x) and carbon monoxide (CO) pollutant emissions and high thermal efficiency (Dearden et al., 1993, 1996; Dally et al., 2002; Tsuji et al., 2003; Christo and Dally, 2004; Ellul et al., 2006; Noor et al., 2012a). When using the regenerator to recycle the waste heat of flue gases, the thermal efficiency of MILD combustion can increase by 30%, while reducing NOx emissions by 50% (Tsuji et al, 2003). By using biogas as a fuel (Colorado et al., 2009, 2010; Hosseini and Wahid, 2013) or Low Calorific Value (LCV) gas, CO_2 emitted by the combustion will be utilized by biomass, which is the source of biogas.

The effect of Air Fuel Ratio (AFR) to the combustion efficiency has been studied for MILD combustion (Quinqueneau et al., 2001; Kumar et al., 2005; Noor et al., 2012b, 2012c) and hydrogen fueled internal combustion engine (Rahman et al., 2008, 2010). The result shows that the performance of combustion is very much affected by AFR used. Too low or too high AFR will reduce the combustion efficiency. The industrial heating community always uses high AFR setting which is also lean combustion. Lean combustion reduces the fuel cost and unwanted Unburned Hydrocarbons (UHC) gases that are released to atmosphere. The requirement of MILD combustion is the Oxygen dilution and the mixtures preheat. One of the economical ways to achieve this is by utilizing the exhaust gas. Exhaust Gas Recirculation (EGR) was previously used for MILD combustion (Katsuki and Hasegawa, 1998; Flamme et al., 1998; Noor et al., 2012b) and play the role to preheat the oxidiser and dilute the Oxygen. The combustion chamber needs to be enclosed in order to collect the flue gas and it is utilized as EGR. EGR flows downward to mix with incoming fresh air. The EGR ratio is determined based on the dilution ratio that is required by the combustion. The EGR ratio is the volume of flue gas used as EGR over total flue gas. MILD combustion can be achieved when the Oxygen level is between 3~13% (Noor et al., 2012a). The purpose of this study is to simulate and check the AFR on LCV gas mixed with hydrogen and the effect on unburned methane (CH_4) and hydrogen (H_2) for the open burner MILD combustion. A mixture of 50% methane, 20% hydrogen and 30% carbon dioxide was used to make the biogas. The result is then compared to the previous study using different composition of fuel.

MODELLING

The Computational Fluid Dynamics (CFD) modeling was successful in numerically solving many engineering problems (Dally et al., 1998; Davidson, 2002; Wandel et al., 2003; Hekkens, 2004; Rahimi et al., 2006; Mollica et al., 2010; Najiha et al., 2012a, 2012b). There are many researchers (Galletti et al., 2007; Parente et al., 2008; Mardani et al., 2010; Mardani and Tabejamaat, 2010; Mardani et al., 2013) are using numerical simulation method and successful to study the MILD and flameless combustion. The open burner MILD combustion was modelled (Figure 1) using ANSYS14.5 design modeler and simulates using FLUENT 14.5 with the size of 1.9 m height and 0.6 m width. This model is a modified version from the previous model (Noor et al., 2012c). Typical data for the burner was shown in Table 1.

The fuel and air injection nozzles were designed as a bluff body to help the mixing process. The fuel nozzle was in the middle with the diameter of 1 mm and annulus air nozzle around the fuel nozzle with the opening size of 1,570 mm^2. The combustion chamber consists of four EGR pipe with inner diameter of 1962.5 mm^2 each. The MILD combustion simulation involved the solution of the chemical reactions, turbulent flows, heat transfer and species transport. Non premixed combustion with chemical equilibrium and non-adiabatic energy treatment was used. In this work, the Reynolds-Averaged Navier–Stokes (RANS) equations together with a realizable k-ε turbulence model (Shih et al., 1995) [that developed based on standard k-ε turbulence model (Launder and Spalding, 1974)] are solved. The discrete ordinate (DO) radiation model (Chui and Raithby, 1993) and absorption coefficient of weighted sum of gray gas (WSGGM) model is used in this work. Figure 2 indicates that when MILD is achieved, temperature inside the combustion chambers will be homogenous.

Table 1. Typical data for burner and combustion chamber.

Item	Data
Fuel	50% methane, 20% hydrogen and 30% carbon dioxide
Oxidiser	Atmospheric air and syntactic air at room temperature
Fuel Inlet	1 x 78.5 mm^2
Air Inlet	4 x 78.5 mm^2
Chamber size	Diameter 600mm, Height 860mm
EGR	4 EGR with 1962.5 mm^2 each inlet
Mesh method	Tetrahedrons (Patch conforming method) with 111,975 nodes and 501,831elements
Radiation model	Discrete Ordinate (DO) model. Absorption coefficient: Weighted Sum of Gray Gas (WSGGM) model.

The fuel and air injection nozzles were designed as a bluff body to help the mixing process. The fuel nozzle was in the middle with the diameter of 1 mm and annulus air nozzle around the fuel nozzle with the opening size of 1,570 mm^2. The combustion chamber consists of four EGR pipe with inner diameter of 1962.5 mm^2 each. The MILD combustion simulation involved the solution of the chemical reactions, turbulent flows, heat transfer and species transport. Non premixed combustion with chemical equilibrium and non-adiabatic energy treatment was used. In this work, the Reynolds-Averaged Navier–Stokes (RANS) equations together with a realizable k-ε turbulence model (Shih et al., 1995) [that developed based on standard k-ε turbulence model (Launder and Spalding, 1974)] are solved. The discrete ordinate (DO) radiation model (Chui and Raithby, 1993) and absorption coefficient of weighted sum of gray gas (WSGGM) model is used in this work.

The method of meshing is tetrahedrons (patch conforming) with advanced sizing function of proximity and curvature and detail setting as in Table 2. The mesh inflation for the near the wall was 5 layer with growth rate of 20%. The nozzle mesh element refinement was used for air, fuel inlet, air fuel nozzle and EGR inlet and outlet. Figure 2 shows the meshing elements of 1,477,322 and nodes count of 490,406. The maximum Skewness is 0.904 which is below the allowable limit of 0.98. The maximum skewness must be below 0.98 or the solution will be easy to become divergence error and will not converge as desired (Noor et al., 2013). Fuel enters the burner fuel inlet at the bottom of the burner with 10 mm diameter and 78.5 mm^2 inlet area. If the velocity of the fuel injected is 1 m/s, the volume flow rate for the fuel is 7.85×10^{-5} m^3/s. Air is injected through 4 inlets at the side of EGR with 10 mm diameter each. Total air inlet diameter is 314 mm^2. If the air injected at 1 m/s, the air volume flow rate is 3.14×10^{-3} m^3/s. The ratio of air and fuel nozzle in this study is 5.0. This ratio was based on the previous study that was given AFR of 5.0 to achieve almost zero UHC and unburned hydrogen in EGR pipe (Noor et al., 2012a). The initial air and fuel nozzle ratio in previous study was based on the methane air mass fraction ratio which 9.5:1.

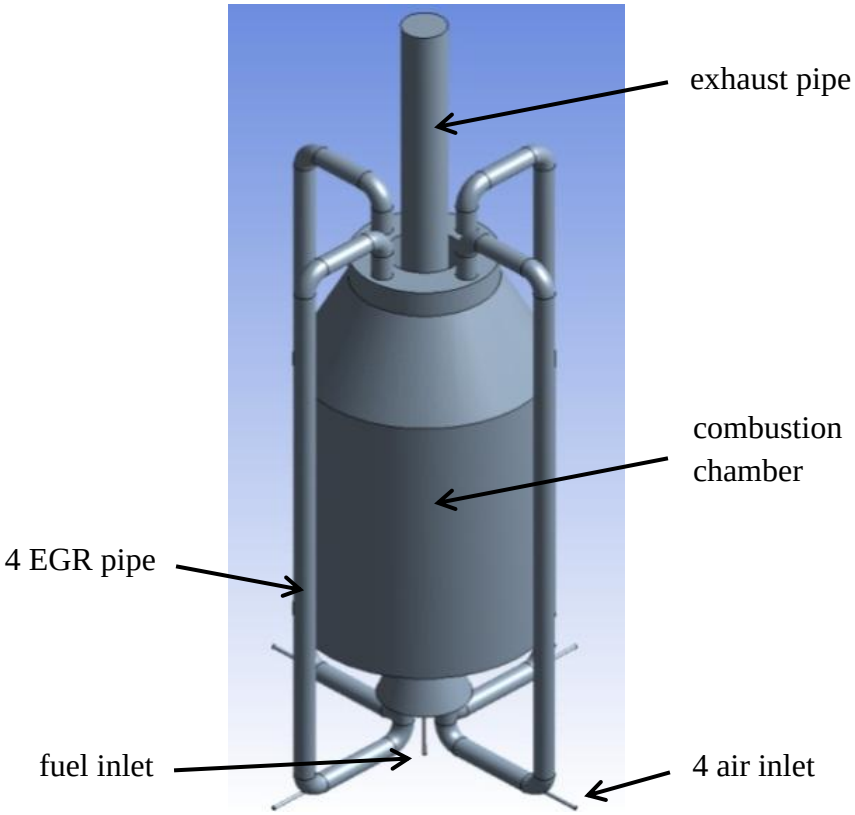


Figure 1. 3D burner geometry with boundary conditions

Table 2. Mesh setting details.

Sizing	Setting
Advance Size Function	On: Proximity and Curvature
Relevance Center	Fine
Initial Size Seed	Active Assembly
Smoothing	High
Transition	Slow
Span Angle Center	Fine

This burner was fuelled by the mixture of methane with hydrogen and carbon dioxide. The fuel mole fraction for this work to produce LCV is given in Table 3. The air mole fraction is 21.008% O_2 and 78.992% N_2. In author earlier paper, the different LCV composition was used with some amount of ethane, propane and butane. In the laboratory for the experimental work, it is not practical to use 7 types of gas (Table 3) as supply and mixing process becoming too complicated and not economical. Thus, three types of gases are analysed in this paper; methane, hydrogen and carbon dioxide. The difference is; the previous study used 86.64% of hydrocarbon mixed with 13.36% CO_2 and this paper used 70% of hydrocarbon and 30% of CO_2. The Oxygen in the oxidiser stream will be diluted by EGR to the required level. The AFR was calculated based on the air and fuel velocity injected to the burner. Due to the different size of inlet diameter between air and fuel, AFR is calculated on volume flow rate of air divided by fuel volume flow rate. The AFR and air velocity that used in this study ranges from 1.0 to 6.5 m/s and 20 to 120 m/s. The total injected volume flow rate into a burner is between

0.0057 m^3/s to 0.0176 m^3/s. The details of AFR and volume flow rate are shown in Table 4.

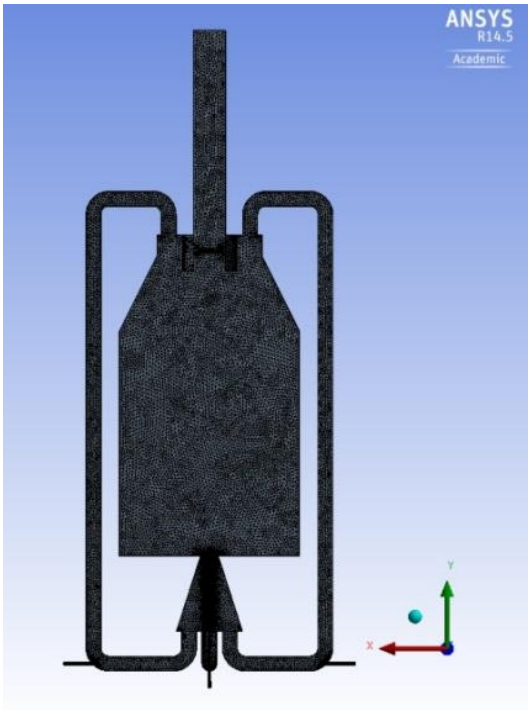


Figure 2. Model after meshing in 2D.

Table 3. LCV gas composition.

Gas	This paper	Previous study (Noor et al., 2012b)
Methane (CH_4)	0.50	0.5344
Hydrogen (H_2)	0.20	0.3000
Carbon dioxide (CO_2)	0.30	0.1336
Nitrogen (N_2)	0.00	0.0130
Ethane (C_2H_6)	0.00	0.0170
Propane (C_3H_8)	0.00	0.0010
Butane (C_4H_{10})	0.00	0.0010

RESULTS AND DISCUSSION

The effect of AFR on the concentration of the unburned CH_4 and H_2 was evaluated using modeled open burner (Figure 1). The simulated results in Figure 3 show that the AFR of 1.0 gives the highest unburned CH_4 at the stoichiometric value 4.17. The initial value of mole fraction for CH_4 and H_2 is 0.5 and 0.20 respectively. The combustion process can be written in general hydrocarbon stoichiometric combustion equation:

$$C_n H_m + \left(n + \frac{m}{4}\right)(O_2 + 3.76N_2) \rightarrow nCO_2 + \frac{m}{2}H_2O + 3.76\left(n + \frac{m}{4}\right)N_2 \qquad (1)$$

Stoichiometric combustion equation (Eq. (1)) with 50% EGR for low calorific value gas consist mole fraction of 50% methane, 20% hydrogen and 30% carbon dioxide by mole fractions. From total flue gas, 50% will flow back to the chamber and lower the Oxygen level in the oxidiser stream.

$$(0.5CH_4 + 0.2H_2 + 0.3CO_2) + (1.1O_2 + 4.14N_2) + (0.8CO_2 + 1.2H_2O + 4.14N_2) \rightarrow (1.6CO_2 + 2.4H_2O + 8.28N_2) \quad (2)$$

Table 4. Air and fuel volume flow rate and AFR .

Air velocity (m/s)	Fuel velocity (m/s)	Air volume flow rate (m^3/s)	Fuel volume flow rate (m^3/s)	Total volume flow rate (m^3/s)	AFR
20	100	0.0028	0.0028	0.0057	1.0
30	100	0.0043	0.0028	0.0071	1.5
40	100	0.0057	0.0028	0.0085	2.0
50	100	0.0071	0.0028	0.0099	2.5
60	100	0.0085	0.0028	0.0114	3.0
65	100	0.0092	0.0028	0.0121	3.3
70	100	0.0099	0.0028	0.0128	3.5
75	100	0.0107	0.0028	0.0135	3.8
80	100	0.0114	0.0028	0.0142	4.0
100	125	0.0142	0.0035	0.0177	4.0
100	120	0.0142	0.0034	0.0176	4.2
90	100	0.0128	0.0028	0.0156	4.5
100	100	0.0142	0.0028	0.0170	5.0
90	82	0.0128	0.0023	0.0151	5.5
120	100	0.0170	0.0028	0.0199	6.0
100	77	0.0142	0.0022	0.0164	6.5

This equation is for the equivalent ratio of 1.0. If equivalent ratio reduces, the fuel reduces and AFR increases. In this study when AFR is equal to 4.0, unburned CH_4 and H_2 mole fraction in EGR pipe is almost zero. The stoichiometric AFR for this fuel composition is 4.17. Comparing to previous study (Noor et al., 2012b) with different burner design and different LCV mixing (Table 3), UHC and unburned hydrogen reaches almost zero when AFR is 5.0. The stoichiometric AFR for this fuel composition is 3.61. Figure 3 shows the comparison of these results and showed when AFR = 4.0 and 5.0, the CH_4 and H_2 mole fraction in EGR were almost zero.

The result in Figure 4 shows that the UHC in flue gas flows through exhaust opening and EGR pipe. Figure 4 shows a reaction from the mixing of the hot UHC and O_2, which is supplied from the fresh air, is happened outside of the combustion chamber such as in the EGR pipe. The reaction is unfavourable. Figure 5 shows a desired combustion with 100% methane and Oxygen consumed by combustion process with achieves MILD combustion state. Figure 6 and 7shows the mole fraction of methane and Oxygen respectively. Both methane and Oxygen were 0% in the combustion chamber and EGR pipe. For Oxygen mole fraction in the Figure 7, there is a small amount of Oxygen on the top of the exhaust pipe. This condition occurred due to the back flow of

the exhaust pipe. Small back flow does not give significant effect the combustion process since the exhaust pipe is long enough to avoid back flow of fresh air into the combustion chamber. The MILD combustion regime can be achieved either fuelled by natural gas or biogas and the performance of a burner remained constant. In both cases, pollution emissions are very low, NO_x emissions are below 3 ppm and CO emissions are below 16 ppm (Colorado et al., 2010). Dally et al., (2010) was successful in achieving MILD combustion by using sawdust as a fuel. Biogas giving 2 % lower efficiencies compare to natural gas. This condition should be compensating by the reduction of greenhouse gases when using biogas as a fuel. These results indicate that the flameless combustion regime can be achieved with different fuels compositions (Colorado et al., 2010).

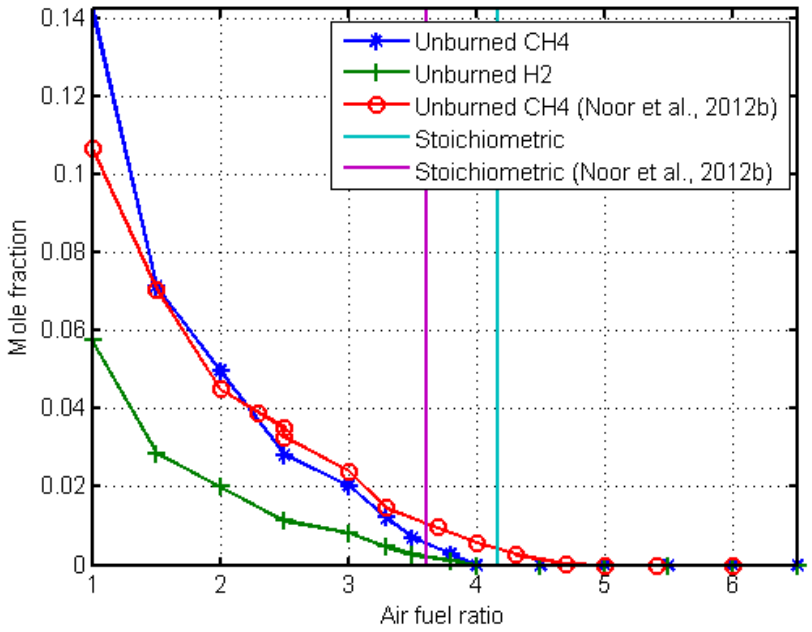
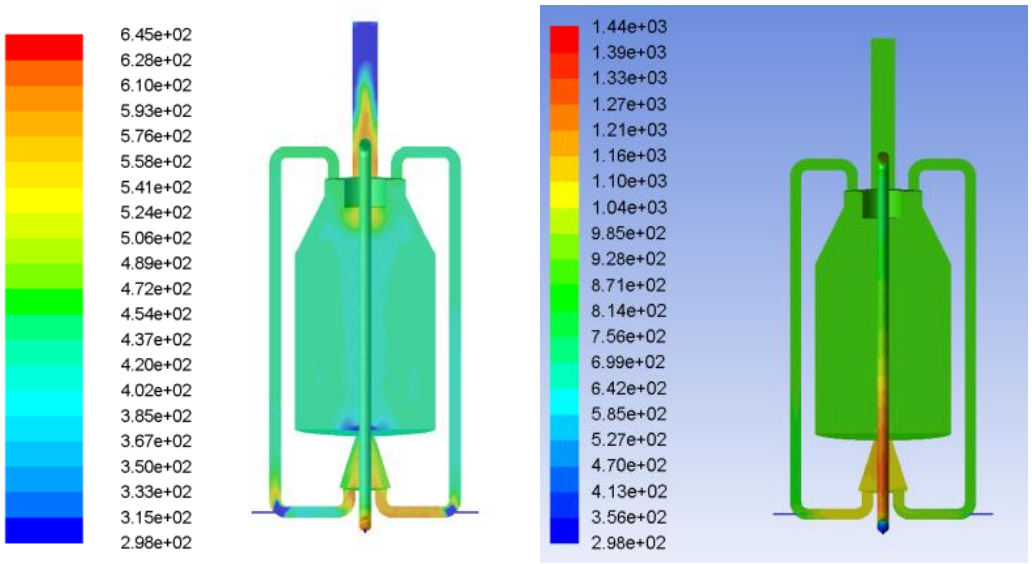


Figure 3. Unburned of CH_4 and H_2 for AFR



(a) (b)

Figure 4. Temperature contour (Kelvin) when unwanted burning in EGR pipe due to unburned CH_4 and H_2 (a) in exhaust pipe (b) in EGR pipe .

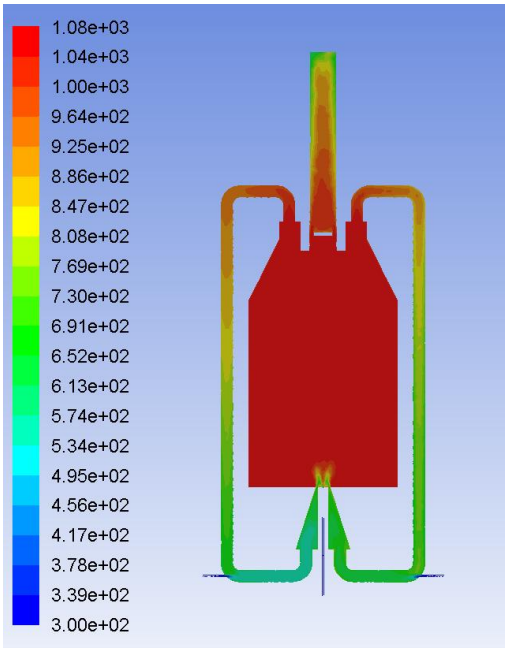
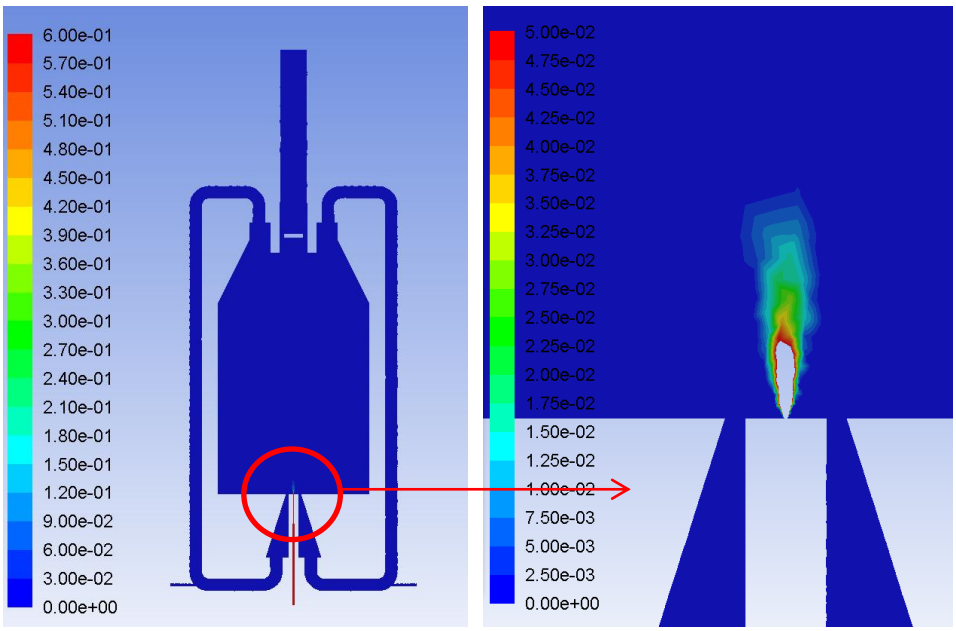
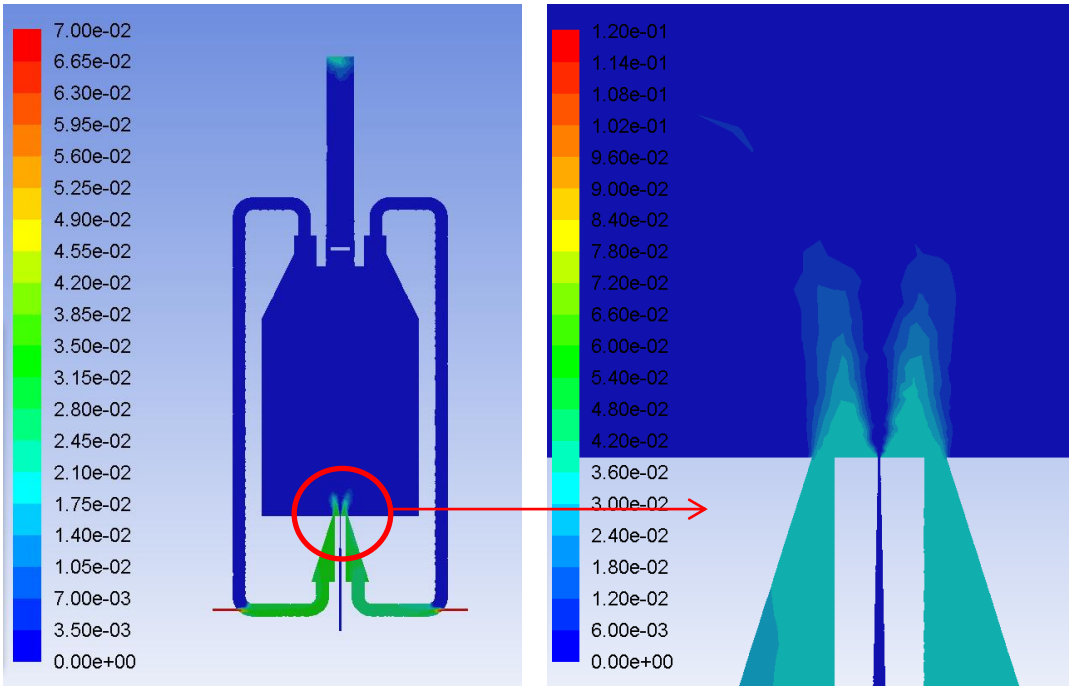


Figure 5. Cross section on temperature contour (Kelvin) when proper MILD combustion with fuel 100% consumed .



(a) (b)

Figure 6. The mole fraction of methane in the combustion chamber and EGR pipe (a) is for the full domain (with a mole fraction range between 0 to 0.6) (b) for a zoomed-in region (with a mole fraction range between 0 to 0.05).



(a) (b)

Figure 7. The mole fraction of Oxygen in the combustion chamber and EGR pipe (a) is for the full domain (with a mole fraction range between 0 to 0.07) (b) for a zoomed-in region (with a mole fraction range between 0 to 0.012)

CONCLUSIONS

The present paper concludes that AFR for the biogas mixed with 20% hydrogen is giving lower AFR than the 30% hydrogen. For biogas mixed with 20% hydrogen, the achieved ARF is 5:1 and biogas mixed with 30% hydrogen, the achieved AFR is 4:1. The simulation results deduce that unburned fuel or UHC will be in the exhaust gas when not enough Oxygen is supplied to the combustion chamber. Air and fuel plays the important role to complete the combustion process. In the combustion process, to consume all the fuel, AFR must be higher than 4:1. Otherwise, the combustion process will produced unburned methane and hydrogen. This condition is called rich fuel combustion. UHC is a waste of fuel and it is part of the environmental pollution.

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THE STUDY OF TEMPERATURE DISTRIBUTION AND HEAT FLUX PATTERNS IN WATER HEATER PLANT

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ABSTRACT

Placement of sensors at optimal location is practically increased the accuracy and reliability of system performance especially for detection of any uncertainties and faults. This study proposes a new sensor placement optimization method for multiple faults detection and diagnosis for thermal process plant. The thermal process plant consists of thermal distribution of the point heat sources that was assembled in the water heating system that is applied in water treatment process. By knowing the temperature distribution, a new algorithm of sensor network will be developed in order to get the optimum measurement. In this case, the actual fluid temperature distribution and total heat flux of the thermal system have been simulated in determining the suitable sensor placement for fault detection.

Keywords: Temperature distribution; algorithm; sensor placement optimization; fault detection; heat flux.

INTRODUCTION

Sensor technologies have been adopted in various scientific and commercial applications. The number of sensor for monitoring and control tasks in the automotive industry, automation technology, medical technology, food industry and in critical process like nuclear power plant has been highly increased by the ongoing technology development in the past years (Reitz et al., 2008). To date, researchers have studied on reducing the cost in sensor environment. According to Lee *et al.* (2011), "Technology advances, decreasing production costs and increasing capabilities have made sensor networks suitable for many application fields". Measurements in industrial process ensure product quality and operational safely. In a safety critical process like nuclear plant, sensors measuring process variable are important to ensure the plant safety (Mehranbod et al., 2003). Measurement errors can occur due to sensor malfunction (fault) or a complete failure. In industrial process, uniformity is essential. Wrong placement of sensors in the plants will contribute to the multiple fault readings. It makes the reading become inaccurate. Sensor fault is a deviation from its normal reading and can be classified into 4 types: bias, drift, precision degradation and malfunction fault (Abdelghani et al., 2007; Qin et al., 1999). Conventionally, two systems are used to deal with sensory faults, preventive maintenance and condition based maintenance by checking, calibrating the sensors and monitoring a process real time condition in order to detect sensor faults (Kusiak et al., 2009).

Prompt detection and diagnosis of faults in industrial system are essential to minimize production loss and to increase the safety of the operator and equipment. For temperature management, essential requirements are fast response behaviour of the sensor and a preferable small impact to the flow of refrigerant (Reitz et al., 2008). In modern industrial production process, the actual displacement of fast moving objects often needs to be detected and is ideally done without the use of any mechanical contact (Zhang et al., 2006). Process and monitoring system has driven the sensor placement activity in order to meet the objectives well. Processing measured data in measurement system can be used to detect and isolate faults and failures (Al Jabbari et al., 2007). Optimal sensor location of measurement points should be taken into account seriously (Chien et al., 2011). As stated by Wang et al., (2011), "To maximize the average detection probability of all the monitored, optimal sensor displacement should be found.

The optimal sensor placement strategies have been developed recently with different methods and techniques to detect and diagnose the sensor faults. Diverse algorithms employ various mathematical techniques to determine the positions of sensors such as multilateration (Niculescu et al., 2003; Lim et al., 2005) multidimensional scaling (Shang et al., 2003; Shang et al., 2004) and mathematical programming (Gentile, 2005; Biswas et al., 2004; Doherty et al., 2004). The placement of sensor is optimum if sensor configuration that maximizes the diagnosability and achieves the minimum capital cost while observing prespecified performance criteria (Commault et al., 2007; Krysander et al., 2008; Fijany et al., 2005). According to Wang et al., (2011), "Data fusion and advanced optimization techniques from Computational Fluid Dynamics (CFD) analysis able to find the near optimal sensor placement solution and it will contribute to the improvement of detecting hot servers in data centres."

OPTIMIZATION

Recent technological advances have incorporated optimization system in any process design in order to face the critical challenge in the system engineering. Optimization is the procedures that make a system as effective or functional as possible with involvement of some mathematical techniques. In the former case, optimum values of design variables are sought for each instance of the design dependent parameter set. The specific mathematical methods used vary in degree of complexity and depend on the system under study (Benjamin et al., 2011). A large number of approaches have been proposed for optimizing the systems. Berry et al. have considered two algorithms, Mixed Integer Programming (MIP) and a fast heuristic (GRASP) which are closest to an approach using in water sensor networks optimization (Berry et al., 2006). Deploying sensors in a large water distribution network is considered by Krause et al. (2008) to reduce detection time and population affected by exploiting the concept of submodularity. By this approach, online bounds on the quality of the sensor networks deployment can be computed (Andreas et al., 2008). Many algorithm approaches have been developed, which try to find good solutions. Algorithm is a set of step by step procedures that provides the correct answer to a particular problem. Online bounds apply to the solutions obtained by the Greedy Algorithm, or by any other algorithm for optimization sensor placement (Andreas et al., 2008). As stated by Mohammad et al., (2007), optimization problem's investigation of the routing path based on the metrics such as distance, power and link usage is to maximize the lifetime of the sensor networks (Azim et al., 2007). Fuzzy Inference System (FIS) has been utilized to optimize the routing path from the available metrics, shortest path, minimum distance,

battery usage and number of packets forwarded previously by the same link which can lengthen the life time of the sensor networks (Azim et al., 2007).

Processes of optimizing systematically and simultaneously a collection of objective functions are called multiobjective optimization (Marler et al., 2004). For a nontrivial multiobjective optimization problem, there does not a single solution that simultaneously optimizes each objective (Eckart et al., 1999). In contrast to single objective optimization, a solution to a multiobjective problem is more of a concept than a definition (Marler et al., 2004). Heuristic for Robust Multiobjective Model (HRMM) is to compute robust solutions in practical situations with an eye to conserve energy in commercial building via providing a robust strategy (Kwak et al., 2012). There are multiple competing objectives like limited energy supplies; demands to satisfy occupants comfort levels, and additional costs to maintain the system. That makes multiobjective optimization is really demanded in this project (Kwak et al., 2012). In that case, the objective functions are said to be conflicting, and there exists a Pareto optimal solutions. Yoon et al., (1995) in Eckart et al., (1999) said "A solution is non-dominated, Pareto efficient, if none of the objective functions can be improved in value without impairment in some of the other objective valves" (Eckart et al., 1999). The desired goal in HRMM is to optimize multiple criteria like achieve maximum energy savings without sacrificing the comfort level of occupants in commercial buildings (Kwak et al., 2012). The most common approaches to multiobjective optimization are to find pareto optimal solutions, used the weighted sum method to aggregate multiple objectives using a prior preference (Kwak et al., 2012).

Methods of nonlinear Multiobjective Optimization (MOO) can be divided into 3 categories, which are methods with a priori articulation of preference, methods with a posteriori articulation of preference and methods with no articulation of preference (Marler et al., 2004). The methods for MOO presented have involved unique formulations that are solved using standard single objective optimization method (Marler et al., 2004).

Genetic Algorithm (GA) approach has been introduced by Holland on 1975. This approach can be tailored to solve multi-objective problems directly (Marler et al., 2004). Genetic multi-objective algorithm also provides an approach for a posteriori articulation of preferences which are intended for depicting the complete Pareto optimal set. This algorithm do not requires solving a sequence of a single objective problem. In order to ensure the reduction of computational burden of the Generic algorithms, Hybrid approaches have been used successfully (Marler et al., 2004). As a whole, genetic multi-objective algorithms are easy to use and receive a high rating for program complexity and this is based on the assumption that it requires the development of a new code (Marler et al., 2004).

RESEARCH METHODOLGY

In a unit operation, there is a water heater that heats the water to a certain level of temperature. In order to optimize the sensor reading using a developed algorithm, finite element method have been used to know about temperature distribution produced by the point heat sources. There are numerous advantages of the finite element analysis. This code analysis of finite element is less complicated than many of the word processing and spread sheet packages found on modern microcomputers (Roylance, 2011). FEA uses a complex system at points called nodes which make a grid called a mesh (Onwubolu, 2012). Nodes are the level of stress indicator for the particular area.

Regions with higher density of nodes will receive large changes of stress and then will experience little or no (Onwubolu, 2012). In this study, heat transfer module is used to analyse model of water heater which is part of the drying process. In this module, temperature distributions have been analysed to get the best placement of the sensor at the end of the study.

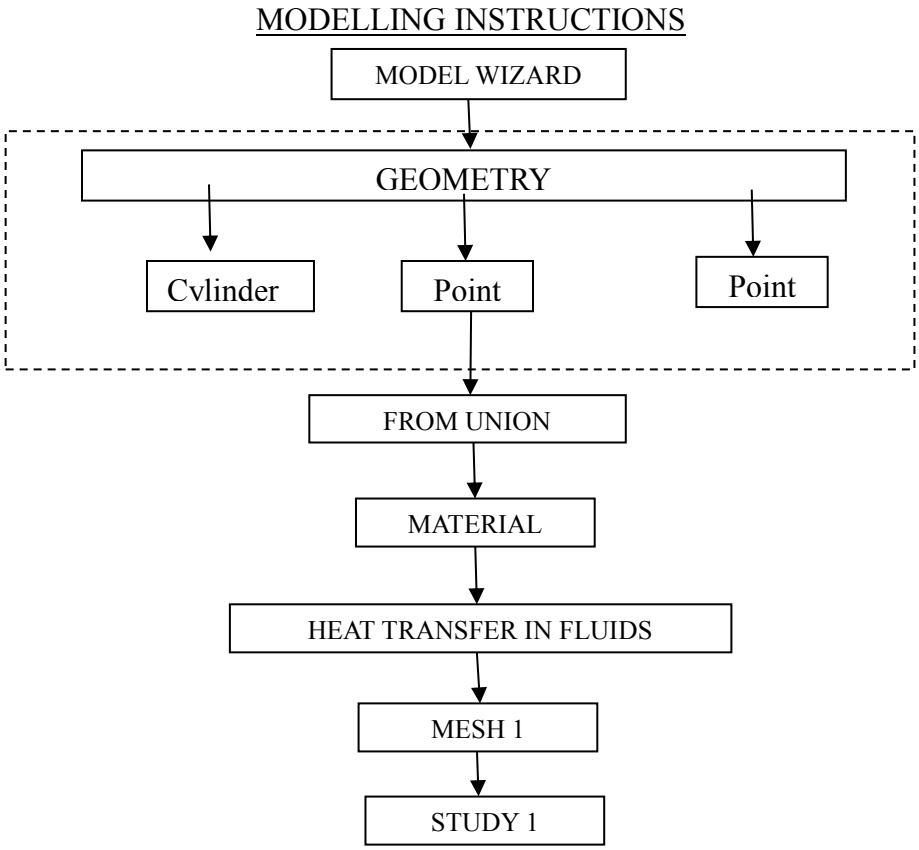

Figure 1. Flow chart of modelling development.

RESULTS AND DISCUSSION

Figure 2 shows the temperature distribution of the point heat sources. There are two points acted as the sources of heat which each contributed to 5 x 10^3 W/m.K. The range of recorded temperature is starting at 293.15 K. From the procedures above, the location of points are fixed at (0.2, 0.2, 0.4) and (0.2, 0.2, 1.0) to represent each heating elements which are able to heat the water in the cylinder container. The highest temperature has been recorded at surrounding of the both points which is recorded 15786.17 K. The readings slightly decreased when the points are more apart from the main sources. Figure 3 shows a combination of contour and arrow table which are represent the total heat flux and the value of temperature for the water heater respectively. It can be seen that the total heat flux hit the highest amount at the point sources since the volume of the arrow is high at that point and become fuzzy at distant point. The fuzzy arrows will contribute to the low number of total heat flux. Heat flux is defined as the rate of heat energy transfer through a given surface and it can be measured in W/ m^2.

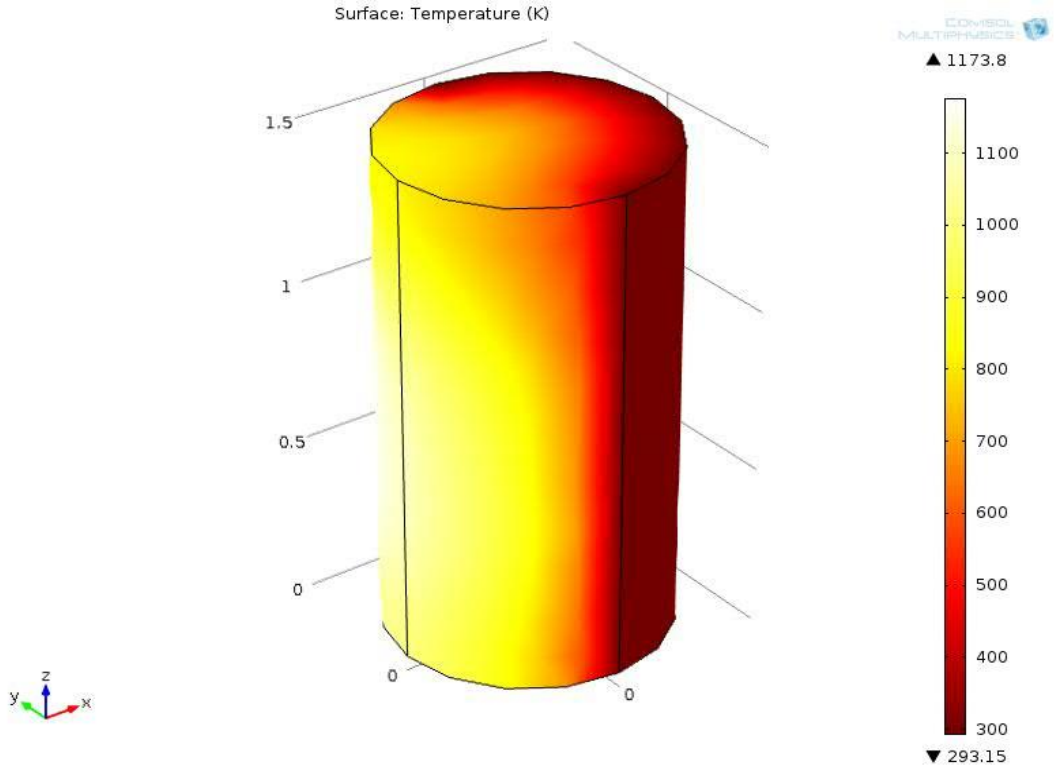

Figure 2. The first default plot is a revolved 3D plot visualizing the temperature field on the surface.

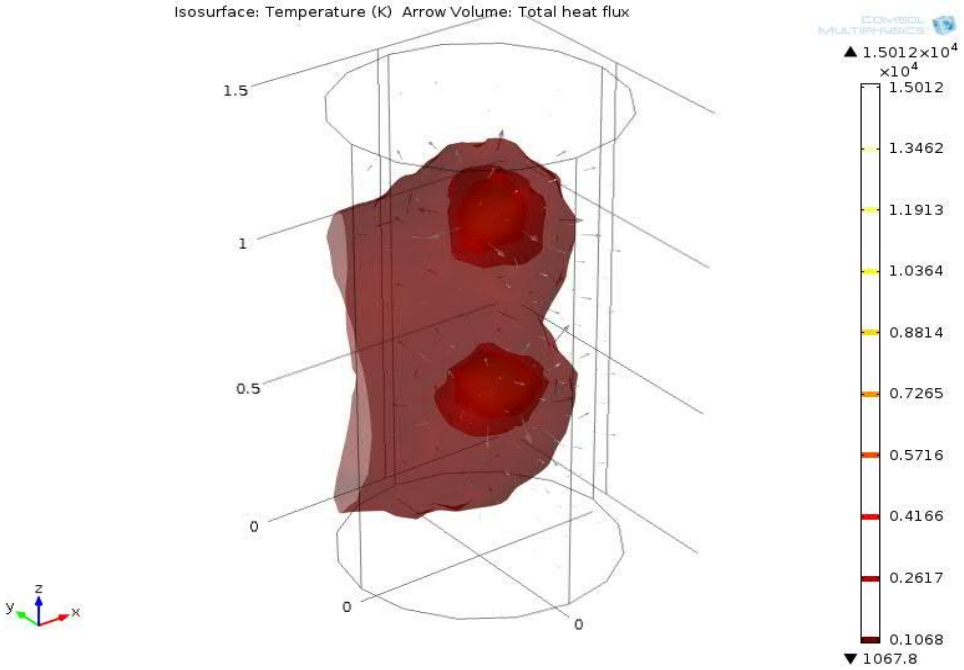

Figure 3. The second default plot is a combined contour and arrow plot of the temperature field and the total heat flux.

* In order to get the temperature value at any point, just click at point in the Graphics window; the result appears in the Results window at the bottom of the COMSOL Desktop.

CONCLUSION

With the doubtful of the reading precision of the sensors in the unit operation, the patterns of temperature distribution have been studied in order to get the best placement of the sensors. Study on the effect of fluids flow to the temperature distribution will be conducted in the future. Comprehensiveness of the temperature distributions' variation is very important due to the sensor readings optimization.

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WAVE PROPAGATION SCATTERING DUE TO DEFECT ON THIN COMPOSITE PLATES

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ABSTRACT

The engineering structures which based on laminated composites, have a high probability of unexpected damage development during services. The damage formations must be monitored from the beginning before it headed towards structural failure which could result in substantial damage. This lead to the necessity of Structural Health Monitoring (SHM) system to be installed during the construction of laminated composite structures. However, an understanding of damage area detection and damage characteristics is essential, before a SHM system can be integrated into the structures. This article presents the effects of propagating wave propagation through an existing damage on composite plates. Theoretically, a propagating wave that started from any source will vary when crossing an area with damage. This study shows a high frequency wave propagation (kHz range) show different reactions when passing through the damaged area, compared with the low frequency wave propagation. Results of the study will lead to good damage detection method, which utilizing the available vibration source; especially for the condition monitoring of thin laminated composite structures.

***Keywords*:** SHM; wave propagation; wavelet analysis; Gl/epoxy composites.

INTRODUCTION

Composite material is known as one of the catalyst for the growth of modern structures; especially the development of smart structures. For instant, a high ratio of material strength compared to its weight, causing it to become one of the main choices in aircraft construction. However, the structure of the composite material is exposed to the danger of the formation and propagation of internal damage, which barely predictable. Failure of the structure can be started from various causes, either during manufacturing process (e.g. voids) or when the structure is being used (e.g., impact or fatigue). It leads to the strong reason why an effective SHM system needs to be installed in every composite structure. One of the concepts in SHM; so called wave-propagation-based SHM is becoming popular recently. The idea is based on the propagation of acoustic waves. In general, this method is usually referred as guided waves, or ultrasonic guided waves, or Lamb waves. Croxford et al. (2007) has claimed that, the guided acoustic waves perhaps the only detection method that combines an acceptable level of damage detection sensitivity, with significant propagation range. Moreover, waveform analysis of the guided waves can provide more detailed information on the location and nature of smaller defect (Mal et al., 2005). A thorough literature study has been done by Diamanti and Soutis (2010) for the use of Lamb waves in aircraft composite structure and they

concluded that this technique can lead to an active SHM for laminated composite structures; which utilizing embedded piezoelectric wafer into layered composite structures. Composite materials display a wide variety of failure mechanisms as a result of their complex structure and manufacturing processes, which include fiber failure, matrix cracking, buckling and delamination (Orifici et al. 2008). Damages can develop and propagate very slowly from inside the composite layers (e.g. matrix cracks, delamination and matrix-fiber debonding). As a result, it will affect material properties of the composites, such as, the material strength and the stiffness.

Formation of damage such as matrix cracking sometimes can be seen with the naked eye, however, the damage such as delamination, is a silent killer, in which case, it is almost impossible to detect from the surface of the structure. There are various methods, highlighted by the researchers to identify the damage in the composite structure; particularly for thin laminated composite plates such as the Fiber Bragg gratings, ultrasonic, acousto-ultrasonic, x-ray imaging, and acoustic emission (AE) methods (Kahandawa et al., 2012; Popovics, 2009; Muravin et al., 2010; Lam et al., 2009). However, the passive fault detection system was focused in this study, as it that can be used online, more practical, less equipment and relatively cheaper system. One of the main challenges for a passive system is to create the classifying technique which can evaluate the condition of the examined structures. In other words, passive monitoring must combine with a good signal analysis in order to produce a robust and reliable system. AE technique may suit the need. Despite of the fact that AE usage is highly established for metallic materials, however, there is a huge challenge in detecting the good AE signals that can be correlated to any damage formation and propagation; especially involving composite materials.

This present study highlights a different approach/concept which may be an alternative and more practical in the real application. The idea is, to manipulate the available vibration source in order to identify the existence of damage in thin composite plates. This concept can also be considered as a passive monitoring. Consider a composite structure that is constantly exposed to constant vibration; in any frequency range will produce wave propagation in the structure. For thin plates, this wave propagation is called as the Lamb waves. When the wave propagates through areas with damage, such as matrix cracking or delamination, this wave will change its form and some characteristics, as it is affected by the existence of the damaged area. This article will reveal the results of several experiments that have been carried out on a thin composite sample; in which a small hole has been made to indicate the presence of the damaged area.

EXPERIMENTATION

265 mm × 97 mm × 4.4 mm of Gl/epoxy resin laminates with a stacking sequence of $[0^{\circ}]_8$ were fabricated by hand lay-up method. A hole was drilled in the middle of the sample as indicated in the Figure 1. Two sets of case study were done, which were aimed to understand the effect of high frequency and low frequency wave propagation passing through damage area.

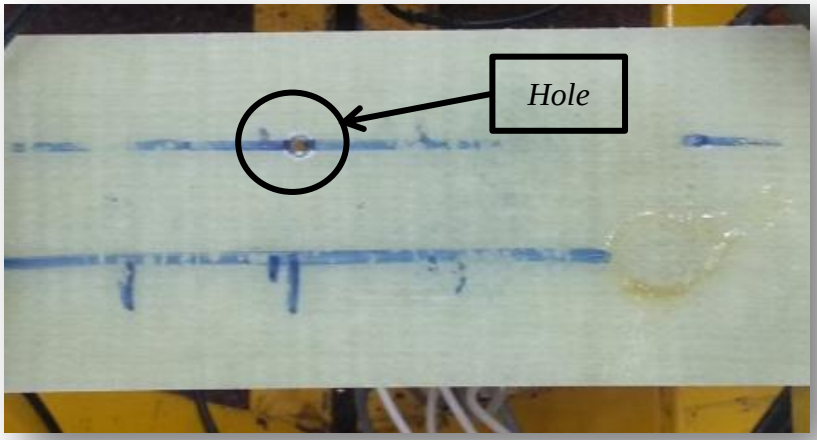

Figure 1. Gl/epoxy resin laminates for the experiments.

High Frequency Case

Figure 2 shows the experimental setup. Two piezoelectric sensors (labeled as number '1' and '2', as shown in Figure 2) were coupled to the surface of the plate. The sensors were individually connected to two PAC AE Node Systems (data acquisition from Physical Acoustic Corporation) for waveform acquisition and were synchronized with the help of *AE Win* software. The sampling rate for acquisition was set to 1 Mega sample per second and threshold was set to 45 dB.

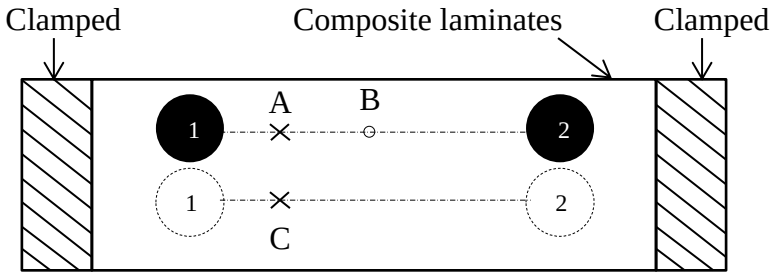

Figure 2. Set-up for 'high frequency source' test.

Point B states the hole's location. Pencil lead break (PLB) test was done at point A. PLB test was chosen as it can excite high frequency wave propagation, approximately 30 kHz. The signal propagation due to lead breaking will be acquired by both piezoelectric sensors. For this case, sensor '2' captured the signal which propagating across the artificial damage area (hole). Finally, for comparison, the lead breaking was also done at point C; as this area has no damage in between the sensors.

Low Frequency Case

The test arrangement was shown as in Figure 3. Both piezoelectric sensors were connected directly to a digital storage oscilloscope and the sampling rate was set to 100 kHz. An impact with hammer was done at point F in order to excite the low frequency wave propagation on the thin plates. The wave propagated and travelled crossing the

point B, and then captured by sensor '1'. At the same time, sensor '2' also detected the same signal; but it was not propagating through any damage area before reaching the sensor. Impacts were repeated at point E and F; where no wave propagation was expected to cross the damage area.

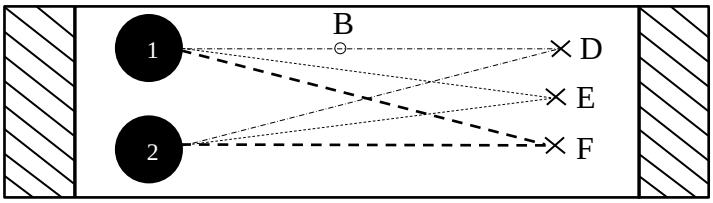

Figure 3. Arrangement for 'low frequency source' test.

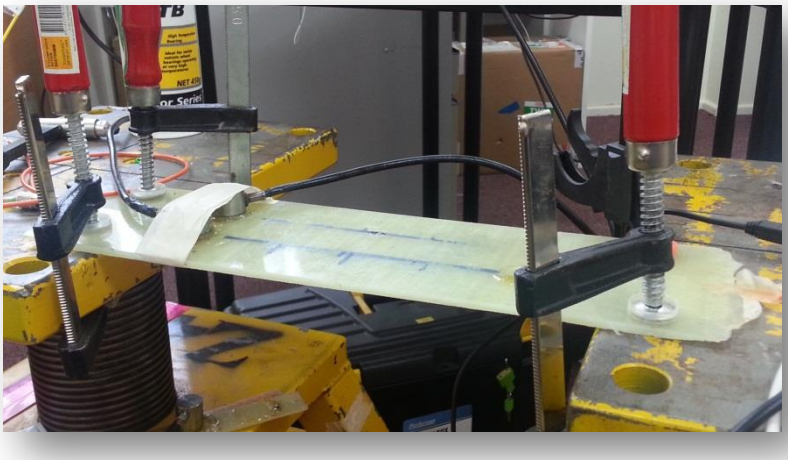

Figure 4. Specimen prepared before the low frequency impact by hammer.

RESULTS AND DISCUSSION

When a Lamb waves propagate past the damaged area, it will experience a wave scattering. The wave scattering effect due to defect on composite materials, has been discussed theoretically by some researchers. Wave scattering is varied depends on the propagating wave frequency range. Based on several experiments that have been done, the propagation of a high frequency wave experienced a very clear wave scattering, compared with the wave propagation of low frequency range.

High Frequency Case

Figure 5 and 6 show the waveform and its respective fast Fourier transform (FFT) of Lamb wave signals due to PLB at point A and C. It is difficult to evaluate the difference between the signals obtained from the two sensors; except an obvious reduction in the signal amplitude and signal energy, which is caused by the effects of attenuation. So too when looking at the results of comparisons of their FFT analysis. Therefore, further analysis is needed to see more clearly the effects of this wave scattering. However, the two major modes of wave propagation still can be observed, which they are always associated with lamb wave propagation; the flexural and extensional modes.

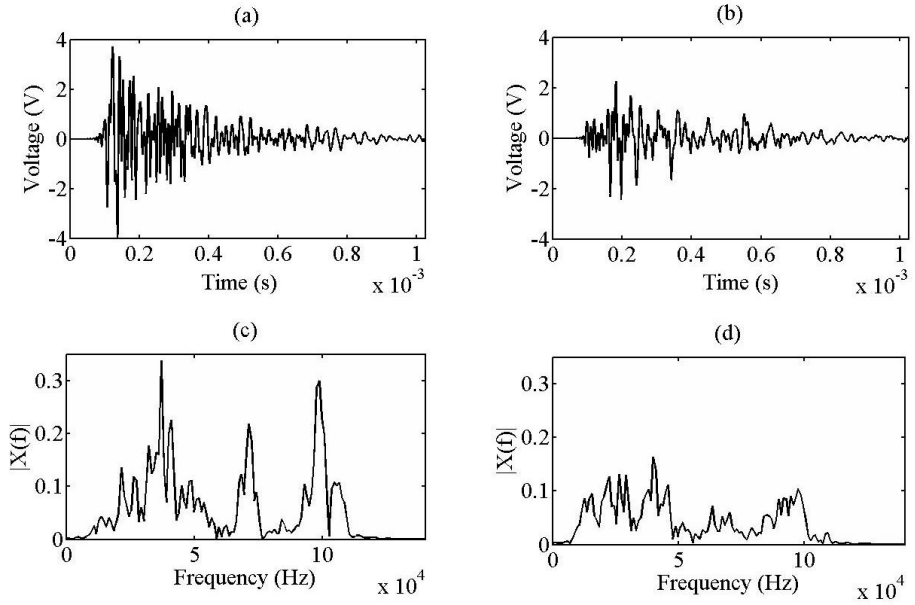

Figure 5. Response due to PLB at point A; (a) and (c) are from sensor '1', while (b) and (d) are from sensor '2'.

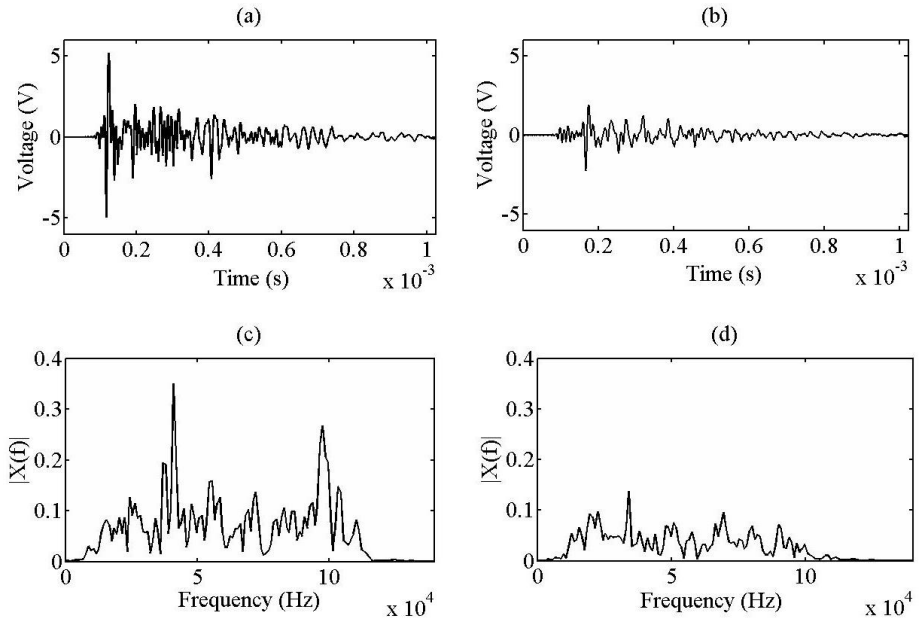

Figure 6. Response due to PLB at point D; (a) and (c) are from sensor '1', while (b) and (d) are from sensor '2'.

Meanwhile Figure 7 shows the result after the Continuous Wavelet Transform (CWT) is performed on the signals. The CWT, one of the time-frequency analyses, can provide extra information from any given time domain signal (Jingpin et al., 2008; Hamstad et al., 2002; Zohari et al. 2012). The CWT of a function, as defined by Chui (1992), can be expressed as,

$$WT_f(s,\tau) = \frac{1}{\sqrt{s}} \int_{-\infty}^{\infty} f(t)\psi^* \left(\frac{t-\tau}{s}\right) dt \quad (1)$$

where $s > 0$ and the superscript * indicates the complex conjugate. The term $\psi(t)$ is the basic wavelet. The parameter s in Equation 1 stands for the scale of basic wavelet and is related to signal frequency. Meanwhile, the parameter τ stands for shift or position of basic wavelet and it can be related to the time of the signal. Plotting wavelet transform magnitude on $s - \tau$ axis gives the time-frequency view of a signal.

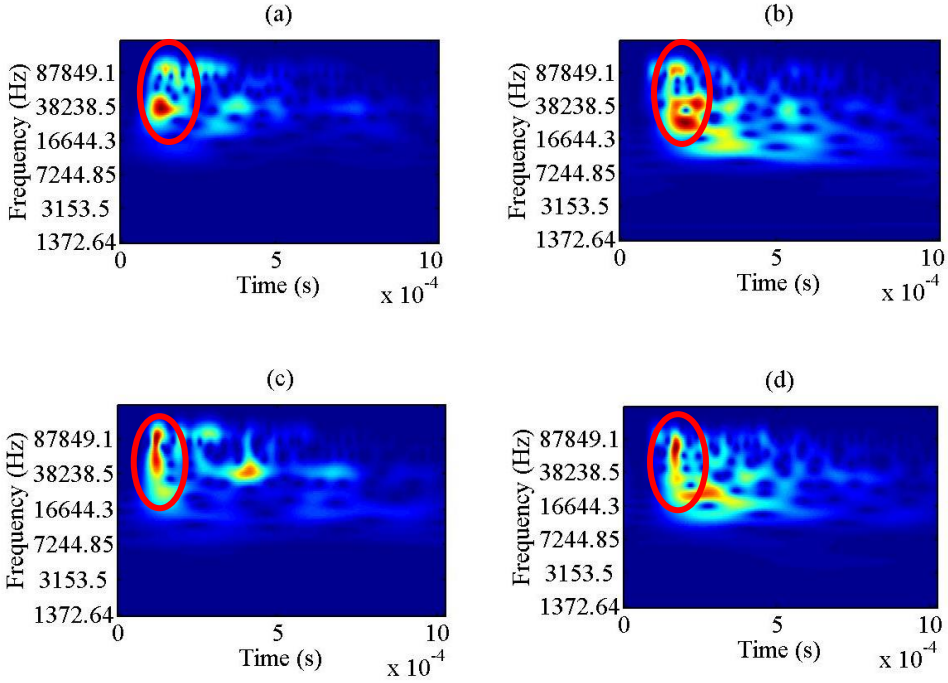

Figure 7. Wavelet analysis of the (a) signal from sensor '1' due to PLB at A; (b) signal from sensor '2' due to PLB at A; (c) signal from sensor '1' due to PLB at C; and (d) Signal from sensor '2' due to PLB at C.

There are many basic wavelets available and appropriate choice of it will give better result. In this study, Morlet wavelet which is identical to Gabor wavelet (Simonovski and Boltezar, 2003) and has similar shape as an impulse (Lin, 2001) was used. It can be defined as (Simonovski and Boltezar, 2003; Lin, 2001),

$$\psi(t) = \left(e^{-i\omega_o t} - e^{-\omega^2/2}\right)e^{-t^2/2} \quad (2)$$

The scale, *s* can be related with the frequency by this relation,

$$\omega = \eta / s \quad (3)$$

where the coefficient η or can be written as wavelet centre frequency, ω_o is depends on the sampling frequency and the selected minimum scale; as explained by Simonovski & Boltezar (2003).

Now then can be clearly observed, the effect of changes in wave propagation which caused by the presence of the damaged area. The circles in Figure 7 (a, b) indicate the changes of the signal waveform in term of time-frequency analysis due to the existence of the artificial damage. Meanwhile, result in Figure 7 (c, d) show no significant variation.

For high-frequency wave propagation (kHz), the overall wave will traverse the existing artificial damage area (hole). This is because the wavelength is very small compared to the size of the hole. As the consequences, this lead to the overall impression of the waves undergoes scattering effect as shown in Figure 7. However, this outcome should not be confused by the wave dispersion and attenuation effect that it always occur when Lamb wave propagate in a thin plate.

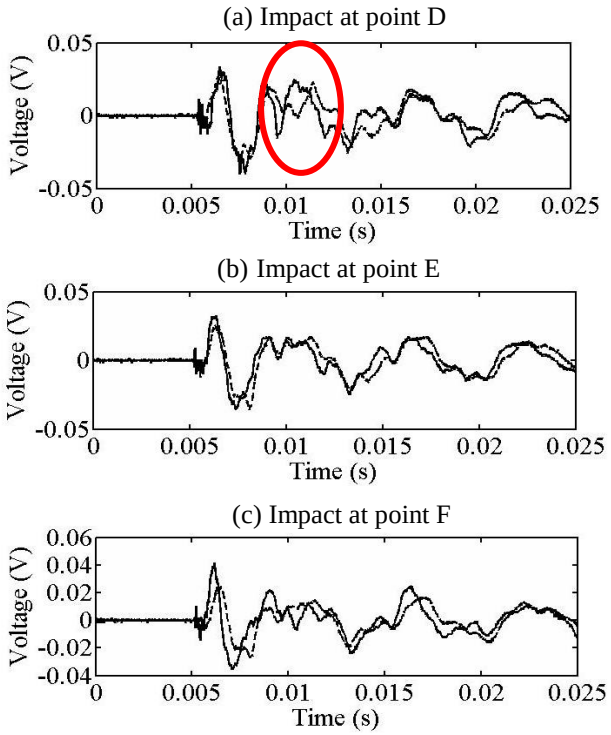

Figure 8. The effect of low frequency wave travelling across the perforated region (indicated by red circle). Two lines in each figures indicated the two waveforms which captured by two different sensors (sensor '1' and sensor '2').

Low Frequency Case

At the meantime, for low-frequency wave propagation, not the entire wave packet traversed the hole at point B. A part of the propagated wave seems to change a little compared with the wave which propagated without passing the perforated region. After a few test, it can be observed that almost 80 to 90 percent of low frequency wave which travel passing the artificial damage area, will have the changes as stated in the result in Figure 8. Figure 8 (a) shows that, if the impact by hammer was done at point D (refer Figure 3), there is a significant variation of the waveform which captured by sensor '1' and sensor '2'; although the waveform actually came from the same source. This situation did not happen if the impact was done at other location (E and F). This is due to none of the source will propagate across the point B (the hole).

CONCLUSION

This study has been successfully reported on the effects of wave propagation traverse the defect area. In the case of a real composite structure, propagation may originate from various sources, such as engine vibration and rotation of the ball bearing. This investigation is still in the early stages and is very useful in order to develop an effective monitoring system for composite structures.

ACKNOWLEDGEMENT

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CORPUS-BASED STUDY ON MALAYSIAN USERS' ENGLISH WRITING: A PRELIMINARY STUDY OF THE COLLOCATIONAL BEHAVIOUR AND SEMANTIC PROSODY OF CAUSE

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ABSTRACT

This paper focuses on collocational behaviour and semantic prosody in the writing of university students in one of the private institutions in Malaysia, and presents preliminary results based on the comparison of data from the literature of corpus-based studies on the lemma *CAUSE*. Ten argumentative essays were compiled and analysed through use of AntConc software. A list of concordance lines were analysed to discover the patterns and collocational behaviour of the lemma *CAUSE*. Inspired by the amount of research that has been carried out with regard to the use of *CAUSE*, this study picks up on some of the adopted and adapted methods from previous research and provides, at least, preliminary findings on the ways *CAUSE* is used in Malaysian students' writing. Given this, the paper hopes to add on to existing findings of the use of *CAUSE* and perhaps, introduce or promote corpus-based methods in language research.

***Keywords*:** Collocational behaviour; semantic prosody; corpus-based studies.

INTRODUCTION

'Sometimes, individual words can trigger assumptions and frames of reference, and words can acquire implications if they are repeatedly co-selected with other words' (Stubbs, 2002: 7). For example, Stubbs found that the word GOSSIP in a large collection of texts, frequently occurred in phrases with very negative connotations such as:

- baseless gossip; gossip-mongering; idle gossip; juicy gossip; name-calling and malicious gossip; scandal and gossip; sleazy gossip; titillating gossip; her affairs became common gossip

Following this, research has also realized that this happens to be the case with *CAUSE* (Stubbs, 1995; Sinclair, 1996; Louw 2000; Partington, 2004; Xiao & McEnery, 2006; Dam-Jensen & Zethsen, 2008). In most of these studies, *CAUSE* is analysed with regard to all its possible forms i.e. *cause, causes, caused* and *causing*, in which we call the *lemma*. Motivated by this, the current study explores *CAUSE* and how it is portrayed in Malaysian students' English writing. In observing the lemma *CAUSE*, it can also be assumed that the vocabulary of the learners' are investigated (Stubbs, 2002). Given this, the study can present results that are two-fold: to identify the pattern and occurrence of *CAUSE* in a Malaysian learners' writing as well as the learners' vocabulary knowledge of *CAUSE* itself.

Corpus linguistics

We could reasonably define corpus linguistics as dealing with some set of machine-readable texts which is deemed an appropriate basis on which to study a specific set of research questions. 'The set of texts or corpus dealt with is usually of a size which defies analysis by hand and eye alone within any reasonable timeframe [and] corpora are invariably exploited using tools which allow users to search through them rapidly and reliably' (McEnery & Hardie, 2012: 1-2). Some of these tools, namely concordancers, allow users to look at words in context. Most such tools also allow the production of frequency data of some description, for example a word frequency list, which lists all words appearing in a corpus and specifies for each word how many times it occurs in that corpus. Corpus linguistics then is basically the study of language through use of computers and machine-readable texts also known as corpus.

Baker (2006: 1) describes corpus linguistics as 'the study of language based on examples of real life language use' (as cited in McEnery & Wilson, 1996: 1). However, unlike purely qualitative approaches to research, corpus linguistics utilizes bodies of electronically encoded text, implementing a more quantitative methodology, for example by using frequency information about occurrences of particular linguistic phenomena. Corpus-based studies typically use corpus data in order to explore a theory or hypothesis, typically one established in the current literature, in order to validate it, refute it or refine it. In the present study, the researcher adopts the corpus-based approach in exploring the lemma *CAUSE* in Malaysian students' English writing.

Semantic prosody

The concept of semantic prosody was originally outlined by Louw (1993) and has been the subject to considerable criticism and debate ever since (Whitsitt, 2005). Semantic prosody –also referred to as discourse prosody by authors following Stubbs' (2001) usage –is a concept that relates to a concordance-based analysis of collocation. This means that 'words or phrases are said to have a negative or positive semantic prosody if they typically co-occur with units that have a negative or positive meaning' (McEnery & Hardie, 2012: 135-136). Simply put, semantic prosody is a term used to describe when words or phrases have certain evaluative meaning to it, either being negative, positive or neutral. Among one of the pioneering studies on semantic prosody, Stubbs (1995) investigated the lemma *CAUSE* in three contexts (by looking at its entries in several dictionaries; by studying the 250 occurrences in a 1 million word corpus; and by using software to analyse further examples from small corpora and 38,000 occurrences in a 120 million running words) and discovered that *CAUSE* is overwhelmingly used in contexts where cause and effect are unpleasant. Stubbs concludes that the main collocates concern problems, trouble and damage, death, pain and disease.

There are many ways to analyse semantic prosody and as Louw argues, 'a semantic prosody can only be discovered by analysis of a concordance' (1993: 159). This may be due to the possibility that semantic prosodies are not necessarily accessible to intuition, which is often used to make judgments about the connotations of a word. Given this, it was deemed most appropriate to adopt the corpus-based approach in investigating *CAUSE* in a corpus of Malaysian students' English writing.

REVIEW OF THE LITERATURE

In recent years, the theoretical construct "semantic prosody" has caught the attention of numerous researchers within corpus linguistics, with *cause* being regularly cited as a prototypical example of the phenomenon (Stubbs, 1995; Sinclair, 1996; Louw 2000; Partington, 2004; Xiao & McEnery, 2006; Dam-Jensen & Zethsen, 2008). While many have looked and argued on what constitutes semantic prosody and semantic preference, this study does not intend to add to the debate on terminological difficulties, rather it wishes to contribute to the findings on patterns of semantic prosody existing in a learners' corpus. Having said that, the study hopes to shed light on Malaysian users' awareness of *CAUSE* and its negative prosodic feature that has been typically informed by past research.

Xiao and McEnery (2006)

This study adopted and adapted methods that are presented in the cross-linguistic analysis of collocation, semantic prosody, and near synonymy conducted by Xiao and McEnery (2006), which was based on data from English and Chinese. Exploration was undertaken through three case studies of near synonyms in English and their close translation equivalents in Chinese. Specifically, the following groups of near synonyms in English and Chinese were examined: the *consequence* group, the *CAUSE* group, and the *price/cost* group. For each group, collocation and semantic prosody in English are discussed, followed by a contrastive analysis of the Chinese data. The discussion of the consequence and *CAUSE*-groups of synonyms in English and their close translation equivalents in Chinese suggests that both languages exhibit features of semantic prosody and that near synonyms are normally not collocationally interchangeable in either language as they show different semantic prosodies. While English and Chinese are distinctly unrelated, the collocational behaviour and semantic prosodies of near synonyms are quite similar in the two languages. This observation echoes the findings which have so far been reported for related language pairs, for example English vs. Portuguese (Sardinha, 2000) English vs. Italian (Tognini-Bonelli, 2001), and English vs. German (Dodd, 2000). The concern that they have raised in this study was that 'dictionaries and thesauri (both learners' and non-learners') are not terribly helpful in distinguishing the different semantic prosodies of near synonyms, because they emphasize the denotational meaning of these synonyms words, not their usage' (Xiao & McEnery, 2006: 111). Therefore, this study wishes to identify the collocational behaviour and semantic prosody of the lemma *CAUSE* in Malaysian students' writing and discover to what extent is the problem statement true.

METHODS

By adopting and adapting the methods put forth by Xiao and McEnery (2006), the researcher looked at the collocational behaviour and semantic prosody of *CAUSE* in the corpus of Malaysian students' writing. The corpus is made up of a collection of ten argumentative essays on ten different titles, each not less than 2,000 words in length. The essays are final assessments for third year undergraduate students taking the Academic Writing course at the respective university. Having collected the essays, the corpus makes up of approximately 22,128 words in total. Topics inlude

- Should parents be blamed for teenage violence?
- Should couples live together before marriage?
- Should students be allowed to use mobile phones in schools?
- Should the death penalty be abolished in the United States of America?
- Should gambling be banned in Malaysia?
- Should teenagers undergo cosmetic surgery?
- Should nuclear energy be widely used in Asian countries?
- Should genetically modified food be allowed in Malaysia?
- Should fathers have the right in the decision making of abortion?
- Should caning be banned in schools?

The essays were then loaded to the AntConc software where frequency and concordance lists were made feasible. Based on the word list generated below, there is a frequency of 78 uses of *CAUSE* including its inflections *cause*, *caused*, *causes,* and *causing*.

Table 1. Lemma word form for *CAUSE* and its frequency.

Rank	Frequency	Lemma	Lemma Word Form(s)
2	1728	a	a 1676 an 52
7	1244	be	are 244 be 128 been 28 is 307 m 489 was 38 were 10
30	174	have	had 33 has 57 have 73 having 11
36	137	child	child 29 children 108
49	89	gamble	gamble 7 gambled 1 gambling 81
55	**78**	**cause**	**cause 46 caused 19 causes 4 causing 9**
58	73	use	use 37 used 16 uses 3 using 17

Given the focus of this study, which is to look at the lemma *CAUSE* in context, a concordance list of *CAUSE* was made. A copy of the list below illustrates the many occurrences of *CAUSE* (which is presented in the center of the phrase) in the corpus.

1	cting their children and causing teenage violence, there	ENG1.txt
2	still other factors that cause teenage violence. Theref	ENG1.txt
3	which are most likely to cause teenage violence. First	ENG1.txt
4	s of testosterone, which causing them to act more aggress	ENG1.txt
5	tional instability which causes them to behave violently	ENG1.txt
6	rastic changes and thus, causes them to behave aggressiv	ENG1.txt
7	y the parents fault for causing teenagers to behave viol	ENG1.txt
8	contains violence. This causes teenagers to glorify vio	ENG1.txt
9	ot of violent issues may cause teenagers to mimic the a	ENG1.txt
10	the one to be blamed for causing teenage violence. Moreov	ENG1.txt
11	oughts of antisocial can cause teenagers to have antiso	ENG1.txt
12	ed in fighting. This has caused a lot of teenagers to in	ENG1.txt
13	er at least 10 times and caused the death of his mother	ENG1.txt
14	cting their children has cause the number of teenage cr	ENG1.txt
15	lect their children have caused the growing culture of v	ENG1.txt
16	line their children have caused teenagers to not respect	ENG1.txt
17	lect their children have caused teenagers who involved i	ENG1.txt

18	ected their children nor causing the number of young teen	ENG1.txt
19	claimed that parents are causing teenage criminals gettin	ENG1.txt
20	should not be blamed for causing teenage violence to incr	ENG1.txt
21	cally are most likely to cause their children to take d	ENG1.txt
22	ng involvement will also cause teenagers to become viol	ENG1.txt
23	buse their children have caused their children to mimic	ENG1.txt
24	love their children will cause the aggressive behavior	ENG1.txt
25	unction of a family will cause some troubles in their c	ENG1.txt
26	involve in violence may cause by peer influence. Teena	ENG1.txt
27	e audiences and this has caused teenagers to become more	ENG1.txt
28	ng of teenagers has also caused them to behave aggressiv	ENG1.txt
29	urrent factors which are causing this issue nowadays but	ENG1.txt
30	ers of children that may cause arguments among family m	ENG2.txt
31	cohabitation might also cause an increase in poverty r	ENG2.txt
32	, cohabiting family will cause poverty. Besides, coupl	ENG2.txt
33	York Times, cohabitation caused negative effects toward	ENG2.txt
34	es HIV and AIDS. HIV has caused 5,000 American women die	ENG2.txt
35	of social problems which caused by cohabitation is early	ENG2.txt
36	d that cohabitation will cause higher possibility of ch	ENG2.txt
37	s that cohabitation will cause behavioral problems amon	ENG2.txt
38	us, this will eventually cause them to neglect their st	ENG2.txt
39	s that cohabitation will cause family violence for wome	ENG2.txt
40	ence for women that will cause the couples to become le	ENG2.txt
41	agreed that mobile phone cause many health problem in a	ENG3.txt
42	rotection, 2011). It may cause brain cancer and leukemi	ENG3.txt
43	owave radiation can also cause disturbance in sleep and	ENG3.txt
44	hones in school that can caused a lot of problems and it	ENG3.txt
45	). Eventually, this will cause a change in the moral re	ENG4.txt
46	ard towards religion can cause tension between the peop	ENG4.txt
47	us arguments that it can cause serious psychiatric diso	ENG5.txt
48	wever, gambling habit is caused by occasional gambling.	ENG5.txt
49	that, gambling can also cause family impact. When pare	ENG5.txt
50	start to doubt that they caused the problem because they	ENG5.txt
51	y had increased, it will cause multiple benefits throug	ENG5.txt
52	netheless, gambling will cause economic gaps, local sma	ENG5.txt
53	shows that gambling will cause intimate partner violenc	ENG5.txt
54	y, or even offspring and cause child abuse cases. There	ENG5.txt
55	urthermore, gambling can cause people spend more time a	ENG5.txt
56	. Actually, gambling can cause psychiatric disorder (Em	ENG5.txt
57	ve disorder. This may be cause by several reasons such	ENG5.txt
58	ky. Cosmetic surgery can cause death if it is not consi	ENG6.txt
59	ery is risky as it could cause death. On the other hand	ENG6.txt
60	smetic surgery will also cause excessive bleeding and s	ENG6.txt
61	etic surgeries will also cause emotional and psychologi	ENG6.txt
62	ry. In addition, BDD can cause emotional disorder and g	ENG6.txt
63	incident in Japan which caused nuclear disasters inOkum	ENG7.txt
64	st nuclear disasters are caused by human mistakes such a	ENG7.txt
65	Island and Chernobyl are caused by human error such as u	ENG7.txt
66	use nuclear energy won’t cause major power blackout in	ENG7.txt

67	an prevent many diseases caused by food bacteria without	ENG7.txt
68	ctly kill cells, or even cause DNA mutation. Additional	ENG7.txt
69	that nuclear energy will cause destruction to the Earth	ENG7.txt
70	ll use up a lot of space causing civiliansto be exposed t	ENG7.txt
71	tion inMayak is actually caused by human mistakes from t	ENG7.txt
72	ren, thus this will also cause trauma to children by ca	ENG10.txt
73	hool hurt their body and cause the physical disable in	ENG10.txt
74	they feel like be lonely cause respect. Children who ar	ENG10.txt
75	caning in school is also causes the student no mood to d	ENG10.txt
76	t not why. Spanking will cause a state of extreme distr	ENG10.txt
77	n conclusion, caning can cause children to have psychol	ENG10.txt
78	e same time, caning will cause them to retaliate and re	ENG10.txt

RESULTS AND DISCUSSION

Based on the frequency list, *CAUSE* appears 78 times in the corpus with inflections *cause* (46), *caused* (19), *causes* (4), and *causing* (9) respectively. From this list, further investigation was made with regard to the concordance list of *CAUSE* to identify patterns of collocational behaviour as well as occurrences of semantic prosody. Apart from analysing words collocating with *CAUSE* in the list, the researcher also made reference with the co-text at large when near collocates were not sufficient to provide ample information. Words collocating with *CAUSE* are as follow:

cause: (teenage) violence, teenagers, the number of teenage criminals, (their) children, the aggressive behaviour, (some) troubles, by peer influence, arguments, an increase in poverty, poverty, higher possibility of child abuse, behavioural problems, them to neglect, family violence, the couples to become less confident, (many) health problem, brain cancer, disturbance, a change in the moral reasoning, tension, serious (psychiatric disorder), family impact, *multiple benefits, economic gaps, intimate partner violence, child abuse cases, people spend more time, by several reasons, death, excessive bleeding, emotional (disorder), major power blackout, DNA mutation, destruction, trauma, the physical disable, *respect, a state of extreme distress, children to have psychology problems, them to retaliate.

caused: a lot of teenagers to involve in physical fights, the death of his mother, the growing culture of violence, teenagers to not respect, teenagers who involved in crimes, their children to mimic their negative actions, teenagers to become more confident to conduct violence, them to behave aggressively, negative effects, 5,000 American women died, by cohabitation, a lot of problems, by occasional gambling, the problem, nuclear disasters, by human mistakes, by human error, by food bacteria.

causes: them to behave violently, them to behave aggressively, teenagers to glorify violence, the student no mood.

causing: teenage violence, them to act more aggressively, teenagers to behave violently, teenage violence, the number of young teenage offenders, teenage criminals, teenage violence, this issue nowadays, civilians to be exposed.

Based on the findings, it can be concluded that the collocational behaviour of the lemma *CAUSE* is presumably more inclined of negative evaluations. However, only two cases were reported as occurring out of the norm where *CAUSE* is used in the following two sentences:

(1) Since the economic activity of certain country had increased, it will *cause* multiple benefits throughout the government and society.
(2) Students will be shamed, will not communicate with others, and will avoid socializing and friendships additionally they feel like be lonely *cause* respect.

From example (1), the student could have used a more appropriate verb instead of *cause*, such as encourage, stimulate, ensure, guarantee, provide etc. Judging from this example, it seems that the student only used *cause* for its denotational meaning, which is to make happen, bring about, create or produce among other near-synonyms (Oxford Essential Thesaurus, 2003). What the student might fail to notice is that *cause* is not suitable in the sentence, given the 'increase economic activity' that could have (elevate, stimulate, encourage etc.) 'multiple benefits' for the government and society. On the other hand, it seems like example (2) is erroneous in the sense that meaning cannot be made given the lack of grammatical accuracy on the structure of the sentence. The closest meaning that could be made would have to be that *cause* was confused or used as the short term of *because* and this would still seem erroneous since the feeling of loneliness does not seem to connect with respect. Given this, example (2) should be discarded.

CONCLUSION

Given the examples showed in the corpus, it can be concluded that the collocational behaviour of the lemma *CAUSE* is presumably more inclined of negative evaluations. Having said that, we can assume that these Malaysian students are aware of the typical collocates of *CAUSE* and how it exhibits a sense of negative semantic prosody. The results of this study also describe the Malaysian students' vocabulary knowledge on CAUSE in general. With reference to Xiao and McEnery (2006), this study has shown that semantic prosody is also observable in Malaysian students' English writing. Apart from that, with particular reference to example (1), the study highlights; to a certain extent; the concern that learners of English might have a tendency to accept denotational meanings given by dictionaries and thesauri without really knowing the meaning of a word. Therefore, it is agreed that 'explaining meanings to learners by offering synonyms should be used with caution' (Xiao and McEnery, 2006: 126). Other than that, learners must be made aware of the fact that collocation patterns and semantic prosodies can [also] vary across [different] text categories (126).

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MOTIVATIONS AND EFFECTS OF FOREIGN SKILLED LABOUR ON MALAYSIA'S ECONOMIC TRANSFORMATION

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ABSTRACT

Globalisation has impacted the socio-economic transformation in all regions in the world. The emerging transnationalism is a global scenario resulting in international migration and movement across borders. The pervasive migration, both skilled and unskilled, effects both source and destination countries, including Malaysia. Towards achieving a high-income nation, it is critical to develop a competent workforce across the key sectors of the economy. Whilst it is most ideal to optimise on the local labour force, immediate critical skills gaps need to be addressed by foreign skilled labour. This research aims to examine the overall characteristics, motivation and effects of foreign skilled labour on Malaysia's economic transformation. Drawing the perspective of employers, policy makers, locals (including returnees) and foreign skilled labour, appropriate immigration policy options will be recommended.

***Keywords*:** Foreign skilled labour; returnees; Malaysia's economic transformation; immigration policy.

INTRODUCTION

Globalisation, being transnational in manner, has impacted socio-economic transformation and development in all regions in the world. The emerging transnationalism is a global scenario which results in international migration and movement across borders. Massey *et al.* (1993) offer an overview of the evolutionary theories on international migration, and more recently Castles and Miller (2003) strengthen the migration systems theory by triangulation of evidence. The entire structure, size, direction and complexity of migration changes, and differs across regions and countries. According to United Nations, the global stock of international migrants increased about 40 percent since 1990, totaling 214 million in 2010. It is also reported that remittances to the developing regions exceed Official Development Assistance. According to the World Bank (2012), the official recorded remittances to developing countries reached $406 billion. The significance of international migration in economic development is further emphasised by Lucas (2005). The author demonstrates that there are strong links between international migration and economic development in the lower income countries. Basically, the key motivation of migration is to seek 'greener pastures' for themselves and their families, which contributes to the growth of the host countries. This phenomenon is exemplified by the high migration rate from the North to the South, particularly in the Organisation for Economic Co-operation and Development (OECD) countries. At the opposite stream, the South-North

migration also effectively generates high remittance flows back to the South, spurring the source countries economic development.

International migrants consist of both the highly skilled and unskilled. Both groups play rudimentary role in a well-functioning labour market. This two-sector labour market is cohesive. World Bank (2012) implies that low-skilled foreign labour can complement high-skilled labour. However, it is imperative to rebalance the economy to attract more skilled immigrants and manage the unskilled intakes. Skilled migration assumes increasing importance following the impact of globalisation and liberalisation in trade and services. Lowell and Findlay (2001) advocate that the positive effects of skilled migration often offset the initial negative impact on host countries, mostly the developing ones. The challenge is to have facilitating policies in ensuring a balanced approach in meeting the labour market demand.

Table 1. Summary of systematic review on foreign labour motivation and effects

Studies	**Focus areas**	**Outcomes (skilled/unskilled/general)**
Massey *et al.* (1993)	Theories of international migration	Dissect of migration theories in general; no specific demarcation between skilled and unskilled migrants
Iredale (2001)	Skilled labour (professional) migration theories and typologies	Discuss selective government migration policies to facilitate skilled migrants
Lowell and Findlay (2001)	Effects of skilled labour migration on developing countries and how developed countries can facilitate movement of highly skilled labour, education and training, knowledge sharing	Reflects on contribution of highly skilled foreign labour on developed countries advancement
Castles and Miller (2003)	Globalization characterises international mobility Government strategies employed to regulate immigration	Evaluate impact of migration in general
Lucas (2005)	Linkages between international migration and economic development in the lower income countries	Attest to the temporary need for highly skilled, permanent settlers and less skilled workers in industrialised nation

Iredale (2001) and Khoo *et al.* (2007) substantiate the influence of transnational policy arrangements such as the General Agreement on Trade in Services (GATS) under the World Trade Organisation (WTO). Nonetheless, there remains more to be investigated in the internationalisation of highly skilled labour. In the case of Malaysia,

being part of the Asia-Pacific Economic Cooperation (APEC), there is increasingly more regional integration established. Malaysia has ongoing FTA negotiations such as the Trans-Pacific Partnership Agreement (TPP), and has signed several bilateral and multilateral agreements. Regionally, movement towards the establishment of a unified connectivity framework has profound bearing on migration policies. For instance, the ASEAN Economic Community (AEC) is to be supported by free flow of goods, services, investment and capital, which include skilled labour. Hence, compliance to operationalisation of Mode 4 on Movement of Natural Persons is compelled. However, the measurement of Mode 4 flows poses formidable challenges in providing evidence based policy input.

In brief, although considerable research has been devoted to foreign labour migration in Malaysia, rather less attention has been paid to highly skilled foreign labour in specific. Table 1 provides a systematic review summary of, though not exhaustive at this point of time, of related studies on foreign labour motivations and effects. Hence, this study aims to use Malaysia, with its diverse workforce progressing towards a high-income economy, to better understand the motivations and effects of foreign skilled labour in its economic transformation.

Malaysia as a Case Study to Understand Motivations and Effects of Foreign Skilled Labour

Malaysia is deemed to be stuck in the middle-income trap, and the only way to get out and shift towards a high-income nation, is to develop and create a competent workforce across the key sectors of the economy. The global talent pool, consisting of the Malaysian diaspora and foreign skilled labour, provides compensating inflows to address immediate critical skills gaps, resulting from brain drain and other human capital leakages. With the limited time to achieve a high-income and innovation-driven economy status by year 2020, it is important to get more experienced and skilled labour in the workforce. With global skilled migrants injected into the local pool, positive spill-over effects and exponential benefits will be created. However, there is a great challenge to address the resistance and perception of foreigners displacing locals in terms of job opportunities. More substantive research in this area will provide a strong evidence-support analysis for policy making, particularly in terms of understanding the contributions and impact of foreign skilled labour to the Economic Transformation Plan. Malaysia is slightly different from the other fast developing countries in terms of migration planning. While the emigration of the highly skilled continues to occur, immigration is used as the mechanism to meet the current and long-term skills shortages, but not intended to grant permanent status to the foreign skilled labour. This research will examine the characteristics, motivating factors and outcomes of foreign skilled labour in Malaysia, drawing the perspective of employers, policy makers, the locals as well as the foreign skilled labour.

Figure 1 shows Malaysia's key national development policies and transformation programme to achieve GDP of US$278b and GNI of US$15,000 by year 2020. Despite suffering from the 1997-98 economic down turn, Malaysia continues to demonstrate upward international rankings as shown in Figure 2. However, like many developing countries, Malaysia lacks the required human capital or 'talent' to contribute effectively in the National Key Economic Areas (NKEAs) identified. Whilst efforts are intensified to optimise, nurture and develop the local talent pool, which is more sustainable in the long run, the training process will consume longer time. The labour

market deficit is further exacerbated by brain drain. Hugo (2011) articulates emigration in two trajectories. On one hand, brain drain has negative impact due to the loss of the skilled.

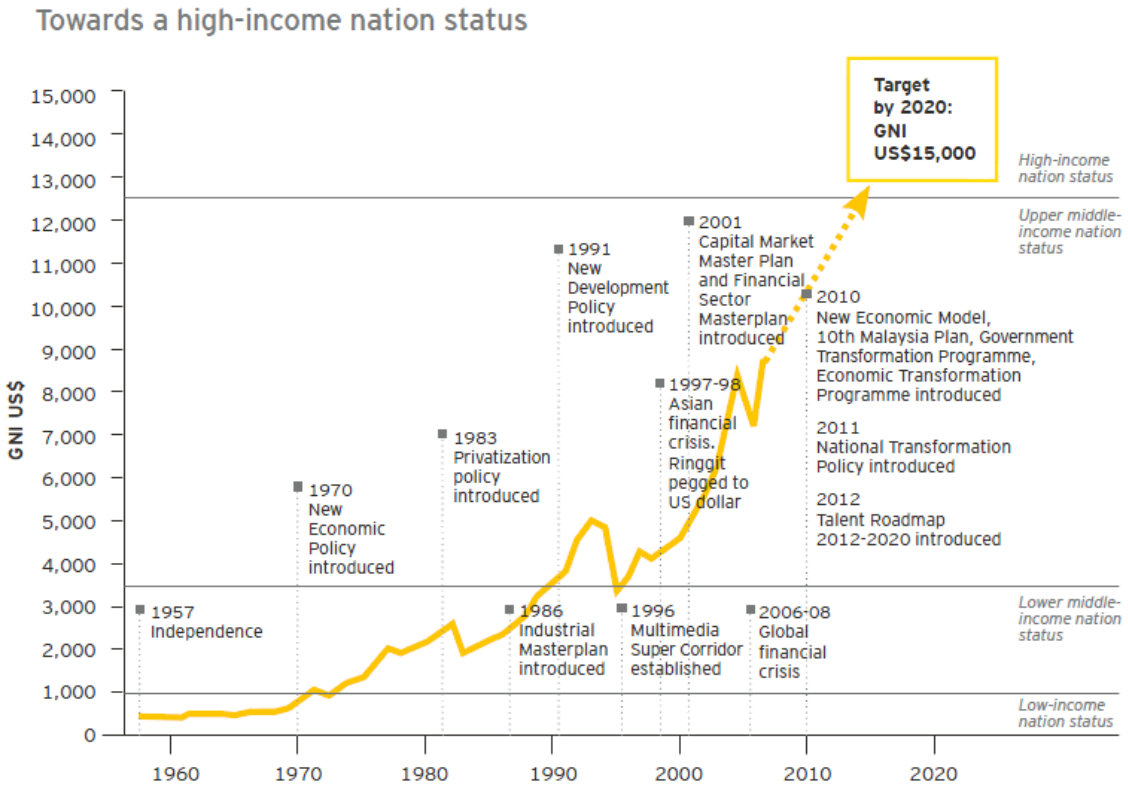

Figure 1. Malaysia as a rapid emerging economy (Ernst and Young, 2012).

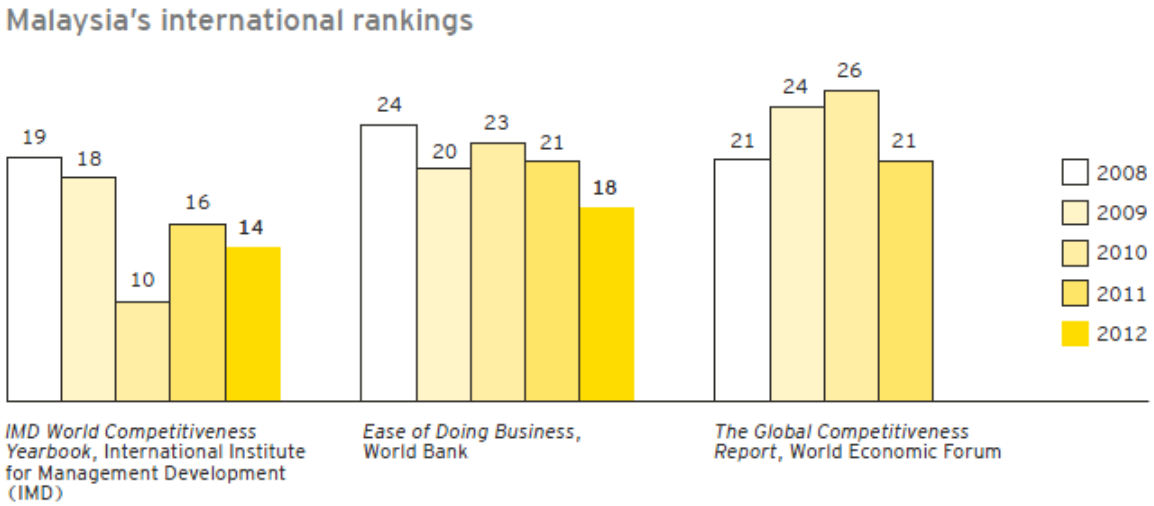

Figure 2. Malaysia's improved rankings from 2008-2012 (Ernst and Young, 2012)

On the other hand, there are various means and ways in which emigration is positive for development for the host countries. As of 1990, Carrington and Detragiache estimate that Malaysia had the highest brain drain of tertiary educated population, and the World Bank in 2010 reports that there are more than one million

Malaysians abroad, of which a third representing the brain drain. Figure 3 illustrates the estimates of the Malaysian diaspora and their locations. Apart from the professional diaspora, many Malaysians go abroad to pursue their studies and some continue to stay upon graduation to look for jobs and other opportunities, further compounding the brain drain negative consequences. According to the 2011 statistics released by the Ministry of Higher Education, there are a total of 89,686 Malaysian students studying abroad. Education contributes to the developed countries in attracting the brightest young potential immigrants (Lucas, 2001). As short term measures, Malaysia leverages on foreign skilled labour in areas where specific skill sets are scarce. Figure 4 shows Malaysia's increasing reliance on foreign labour, leading to job creation for Malaysian workers. However, there exist skeletal studies conducted on the two complementary spectrum of foreign labour, skilled and unskilled.

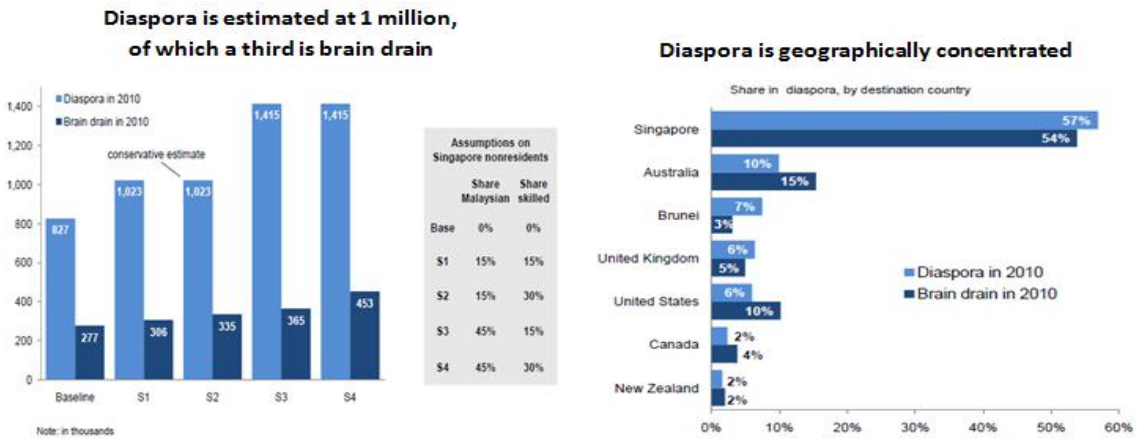

Figure 3. Estimates of the Malaysian diaspora and their locations (World Bank, 2010).

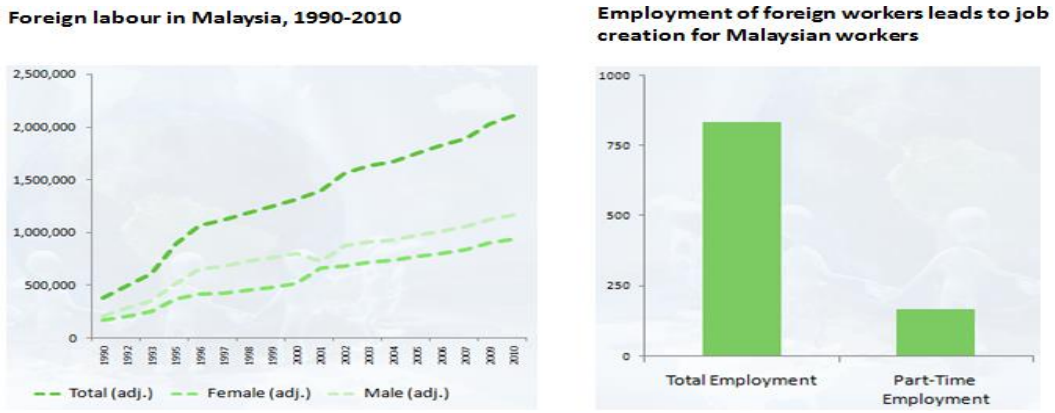

Figure 4. Labour force data on foreign labour (World Bank, 2010).

Skilled labour shortage remains a crucial concern for investors. Based on a perception survey of 1000 odd firms in the manufacturing sector and 303 firms in selected business support services sector in 2007, firms indicate that one of the main challenges they faced was shortage of skills. Figure 5 illustrates the findings of the perception survey in the Malaysia Investment Climate Assessment Report in 2009. Foreign skilled labour are then sought after to fill in the critical skills gaps.

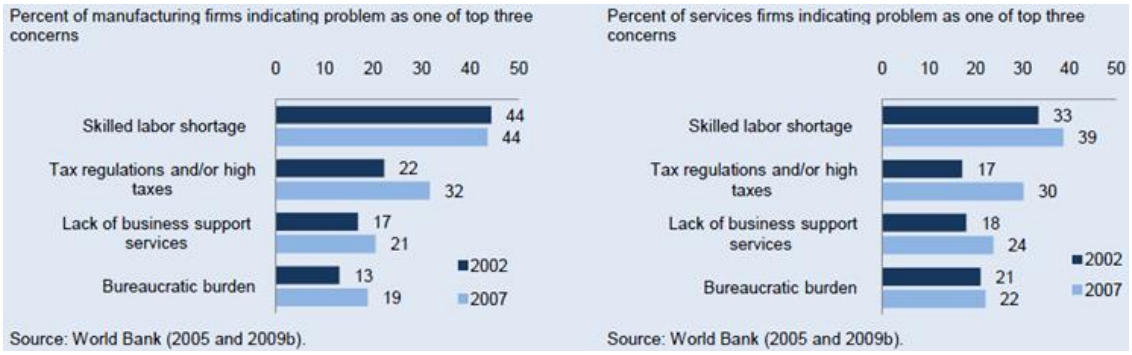

Figure 5. Skilled labour shortage is main investment concern in manufacturing and services.

Both foreign and Malaysian skilled labour are highly complementary. However, the notion that foreign skilled labour are perfect substitutes and displace the locals is still prevalent. The World Bank (2012) indicates that highly skilled foreign labour can help create economics of scale through agglomeration of human capital, generating more high-skilled jobs for Malaysians. The challenge for Malaysia is not to push out low-skilled foreign workers, but rather to rebalance its economy in order to attract more highly-skilled. Nevertheless, it is argued that in facilitating foreign skilled labour to fulfill economic imperatives, national security and socio-economic integration needs to be taken into consideration in parallel.

Research Questions

The fundamental research questions to be addressed in this study include:

a. Who are the foreign skilled labour in Malaysia?
b. Why have the foreign skilled labour migrated to Malaysia?
c. Where have they lived prior to migrating to Malaysia?
d. What are their intentions in the near future? Commitment in terms of asset purchase, investments etc.
e. What are the foreign skilled labour impact(s) to the Malaysian economy?
f. What balanced policy mechanisms would best meet labour market demand?

Research Objectives

Although considerable research has been devoted to assess the motivation and outcomes of foreign labour in Malaysia, rather less attention has been paid to dissect the causes, process and impacts of highly skilled foreign labour. Salt and Findlay (1989), and Iredale (2001) acknowledge that theories on skilled migration particularly in explaining its motivating factors are inadequate despite it being an increasingly large influence in the global migration streams. It would thus be of interest to learn the contexts and motivation for the migration of skilled labour to Malaysia from the perspectives of the employers, policy makers, locals and foreign skilled labour including the returnees. For example, Khoo *et al.* (2007) advocate that having good understanding of the demand factors motivating temporary employer-sponsored skilled migration help in better managing Australia's immigration.

The overriding objective of this research is to better understand the overall characteristics and motivation of foreign skilled labour in Malaysia as well as their role in the economy. Expanding on the existing empirical evidence, this research aims to conceptualise both the functional and structuration perspectives of foreign skilled migration in Malaysia (Goss *et al.* 1995). With the Migration System Theory introduced by Massey *et al.* (1993) as the research theoretical framework, the specific objectives of this research are as follows:

a. To understand and define foreign skilled labour;
b. To assess the mobility patterns, causes, intention of the foreign skilled labour;
c. To investigate the perception, outcomes and impacts of foreign skilled labour in key economic sector(s), particular in education and training; and
d. To develop skilled labour management and policy strategies as well as mechanisms to best meet labour market demand. (Hugo, 2006)

METHODOLOGY

This applied research will adopt both quantitative and qualitative measures. Cresswell (2003) suggest that in mixed method research, questionnaires can be used in conjunction with other techniques. A quantitative web-based survey with both close and open ended questions will be employed to provide a summary of demographic characteristics with the mobility patterns, to what extent are those movement polarised, multi-directional or flexible, motivating factors and contributions of the respondents. The targeted respondents comprise foreign skilled labour holding Residence Pass – Talent (RP-T) based in West Malaysia. The questionnaire will be piloted with selected respondents to seek improvement feedback. Simultaneously, face to face semi-structured interviews will be conducted with 10 to 12 participants identified via non-random purposive sampling. Black (1999) defines purposive sampling as 'hand-pick subjects on the basis of specific characteristics'. This method is best to solicit in-depth information on perceived level of skilled migration, effects on education and training, policy relevance as well as aspiration on foreign skilled labour programme. The participants may consist of policy makers (politicians, bureaucrats, regulatory bodies, trade unions) and locals (employers, returnees).

CONCLUSION

It is anticipated that this research will contribute to both the body of knowledge and policy planning. Its significance hinges on the inadequacy of highly skilled foreign labour research in Malaysia, with the Residence Pass – Talent being a recently introduced immigration instrument. Furthermore, more often than not, perspectives of the diverse stakeholders have not been thoroughly studied with regards to foreign skilled migration in Malaysia. Whilst the Malaysian government perceives both immigration and emigration being too high, there is a lack policy to influence both streams. This research provides evidence-based approach and analysis in immigration policing.

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TEXTILE MATERIAL FORMS FOR REINFORCEMENT MATERIALS – A REVIEW

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ABSTRACT

This paper intended to give an insight of the textile material utilization as reinforcement in the composite materials. The discussion on textile definition and categorization will give some ideas for the reader to recognize textile materials and its role in this system. Simple categorization is referred to which textile materials are clustered into fibre, yarn and fabric regardless whether it is made synthetically or naturally. For every basic textile material form, few selected recent works have been discussed to show the utilization of textile material in research and industry. Composite made of textile fibres form is limited to low and medium load bearing application due to the difficulties of controlling the alignment, dispersion and distribution of fibres. Whereas yarn reinforcement gives more control on the composite materials due to the fibres is aligned in a yarn but the issue is more on the limited fabrication method. Utilization of textile fabric in composite as reinforcement is well recognized for high performance fabric so it is with natural fabric. Nonetheless, there is a limit of work considering fabric properties or parameters when characterize its composite to understand the fabric contribution in composite material.

Keywords: Composite; textile material; fibre; yarn; fabric.

INTRODUCTION

It is well known that engineering material is divided into four clusters which are metals, polymers, ceramics and composites. The first three classes are always been categorized as homogenous materials, and this is the main thing that differentiates them with material. Early definitions of material are rather simple, for instance, Rowell (1990) defined a composite as "a reconstituted product made from a combination of two or more substances using some kind of mastic to hold the components" and Maloney (1996) defines a composite "as materials that have the commonality of being glued or bonded". These two definitions are somewhat general for wood product since they were discussed about wood pulp and wood industries in their papers. Misnon (2007) concluded the definition of materials as a select combination of dissimilar materials with an internal structure and with an external shape or which results to heterogeneous and anisotropic materials. The word heterogeneous and anisotropic make the definition of composite is difficult to achieve because the three classes mentioned (metals, polymers and ceramics), to some extent, are sometimes anisotropic at submicron

dimensions. Therefore, some other good definition, more specific and emphasize the general composite structure is needed. Bader (1997) in his work came out with useful and neat definition for composite as a material is characterized by being multiphase materials (one or more substances, including matrix) within which the phase distribution and geometry have been deliberately tailored to optimize one or more properties.

This is clearly an appropriate definition for textile composite or textile-reinforced composites (TCRM) for which there is one phase, called the matrix, reinforced by a fibrous reinforcement in the form of a textile. Due to a major of textile material involvement in composite material, regardless whether it is synthetic or natural derivation, utilization various versions of materials in the form of fibres, yarns, fabrics, their hybrids and many other combinations since about millennia ago has established their own cluster and definition. Textile composite can be defined as a combination of fibrous material (textile) either fibre, yarn, or fabric embedded in a resin system, and it can be in the form of flexible or quite rigid materials (Scardino, 1989).

Properties of textile composites are strongly influenced by the properties of their reinforcement distribution and the interaction among them (reinforcement and matrix). The geometry of the reinforcement may be described by the shape, size, and size distribution. The reinforcement in the systems may differ in concentration, distribution and orientation. Therefore, all of these factors may be important in determining the properties of the textile composites. To understand the reinforcement concentration, distribution and orientation of textile composite, knowledge of textile material should be taken into account.

The intention of this paper is to give insight of the textile material utilization as reinforcement in the composite materials. Definition of textile material has been discussed in order to give some ideas to the reader of what textile is all about and how these materials were clustered into basic categories. Simple categorization is referred to which textile materials are clustered into fibre, yarn and fabric regardless whether it is made synthetically or naturally. Some figures have also been included to provide a better understanding of the forms of the material being discussed. For each basic textile material form, several research or recent research has been discussed to show the utilization of textile material in research and industry and then followed by the authors' opinion and suggestion related to the textile materials' utilization.

TEXTILE MATERIALS

This term applies to product forms (fibre, yarn and fabric), either they are from natural or synthetic sources as well as the products derived from them. Which includes all types of yarns or ropes (threads, cords, ropes and braided); all types of fabrics (woven, knitted and nonwoven); hosiery (knitwear and garments); household textiles, furnishing and upholstery; industrial and technical textiles (e.g. geotextiles, medical textiles and textile composites). Fibre is a basic unit of textile material and it can be clustered into two big groups, natural and synthetic/man-made fibres. These fibres are not only differed in properties among natural and synthetic, but also differ in their cluster depends on the chemical composition (Kadolph & Langford, 2001). Figure 1 shows some types of textile fibres and its classification while Figure 2 shows some example of fibres.

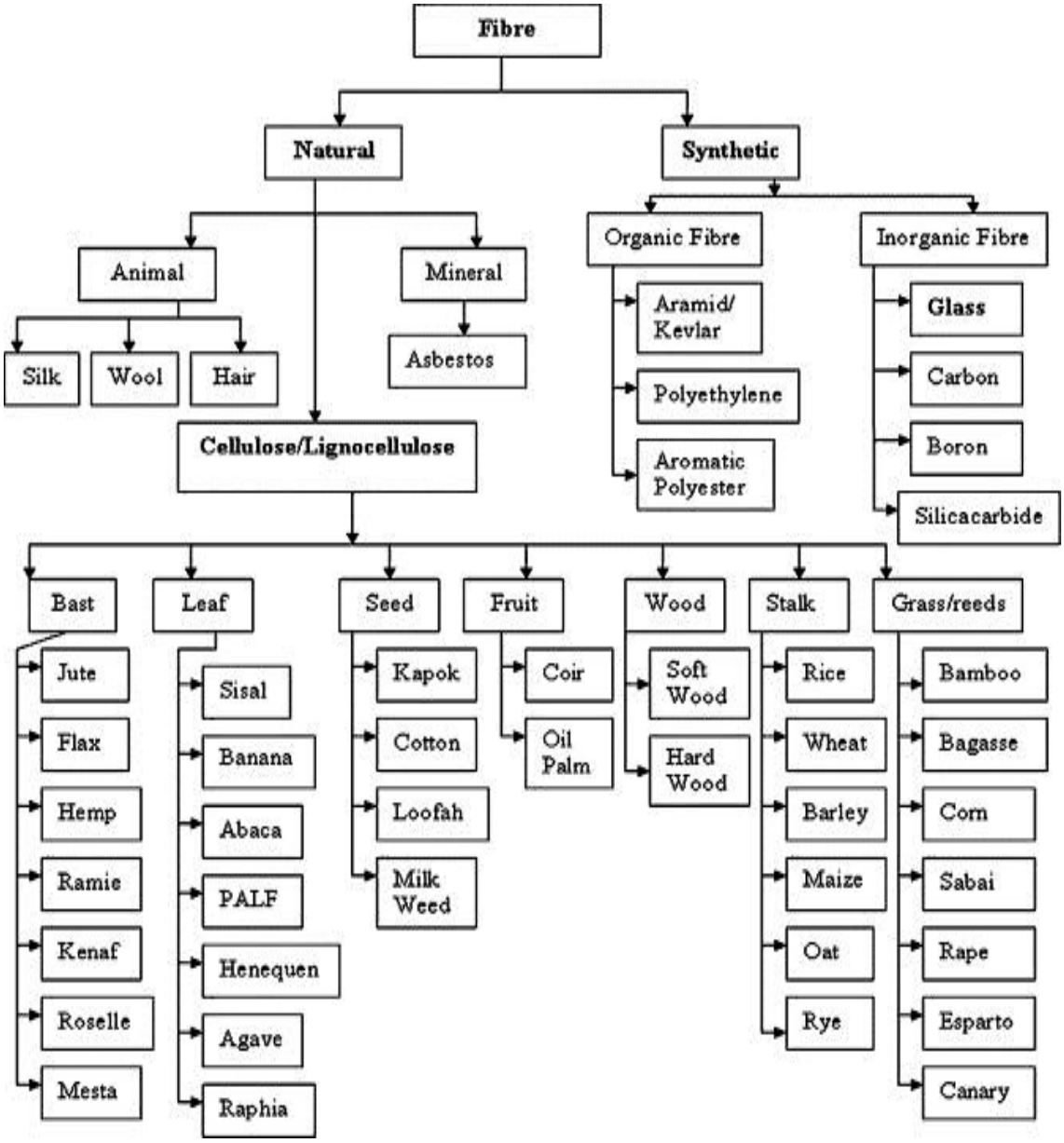

Figure 1. Textile fibre types and their classification (Kadolph & Langford, 2001).

A group of fibres with or without twist is called yarn and it has substantial length and relatively small cross-section. Monofilament is the yarn containing only one fibre for example, nylon. Untwisted, thick yarns are termed tows and this term is usually applied for high performance yarn such glass, aramid and carbon. In twisted yarns, the friction resulting from twist consolidates fibres. A twist is introduced to a continuous filament yarn by twisting. For a twisted yarn made of staple fibres, the process is called spinning and involves a long chain of preparatory operations. There is different yarn spinning processes (ring spinning, open-end spinning, friction spinning) leading to yarns with distinctive internal distributions of fibres. Figure 3 shows some example of yarns.

Figure 2. Examples of textile fibre; (a) Aramid, (b) Glass, (c) Cotton and (d) Wool (Kadolph & Langford, 2001).

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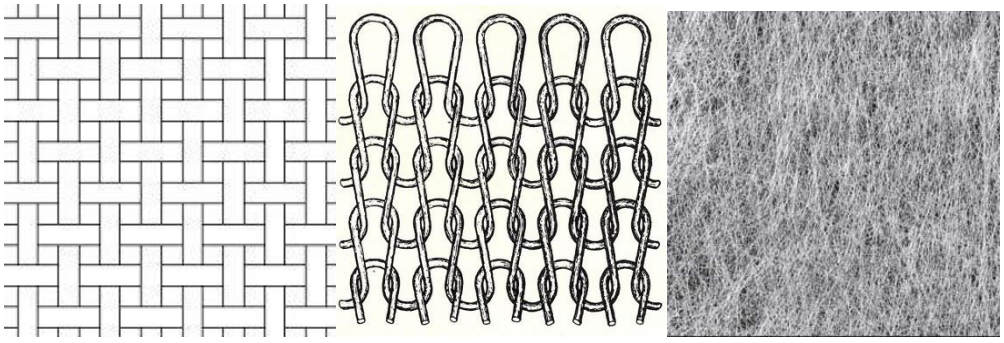
Next transformation of textile fibres after being a yarn is fabrics. Three distinctive common fabric types are woven, knitted and non-woven fabrics produced by weaving, knitting and various non-woven processes respectively. Figure 4 shows different types of fabric structure. Woven fabrics generally consist of two sets of yarns that are interlaced and lie at right angles to each other. The threads that run along the length of the fabric are known as warp ends whilst the threads that run from selvedge to selvedge, that is from one side to the other side of the fabric, are weft picks. Frequently they are simply referred to as ends and picks (Sondhelm, 2000). Knitted fabric consists of interloping yarns either weft (weft knitting) or warp (warp knitting) directions. Warp knitting is a method of manufacturing a fabric by standard knitting means, in which the loops made from each warp are formed substantially along the length of the fabric while weft knitting is a method of making a fabric by normal knitting means, in which the loops made by each weft thread are formed considerably across the width of the fabric (Anand, 2000).

(a) (b)

Figure 3. Example of yarn, (a) Carbon tows and (b) Dyed cotton yarns (Kadolph & Langford, 2001).



(a) (b) (c)

Figure 4. Types of common fabric; (a) woven, (b) knitted and (c) non-woven fabrics (Sondhelm, 2000).

A nonwoven is a textile structure produced by the bonding or interlocking of fibres, or both, accomplished by mechanical, chemical, thermal or solvent means and combinations thereof. It has to be admitted that this definition is not very precise, but it has been chosen because it includes many important fabrics which most people regard as nonwovens. One of the major advantages of nonwoven manufacture is that it is generally done in one continuous process directly from the raw material to the finished fabric, although there are some exceptions to this (Smith, 2000). Fabric types mentioned are the usual single plane structures also known as 2-D fabrics which high performance fibres are available. However, beyond of that, fabric in multi-plane structures or 3-D fabrics can as well be manufactured by weaving, warp knitting, braiding, non-woven and other specially modified techniques. The diverse techniques on fabric manufacturing allow more flexibility on tailoring the textile material which could be used in diverse of applications.

Considering the broad definition of textile and various type of textile material in three different form (fibres, yarns and fabrics), no wonder if textile material can be found not only for apparel and garment but also in technical industry such as automotive, aeronautic, infrastructure, composite etc. Textile can be also defined

according to their hierarchical and several notations for broaden the scope of textile materials (Lomov, Verpoest, & Robitaille, 2005). However, this topic is not the main concern, thus it will not be discussed in this paper.

COMPOSITE REINFORCEMENT

Fibres

Fibre is the basic textile material form for composite reinforcement and with the various types of textile fibre ranging from synthetic and natural, with ranges of properties, ranges of polymers as well as several methods of processing, they offer more possibilities to suit the purposes of end products. Table 1 shows the mechanical properties of some common synthetic and natural textile fibres (Bledzki & Gassan, 1999; Dittenber & GangaRao, 2012; Faruk, Bledzki, Fink, & Sain, 2012). Synthetic fibres are meant for high performance and load bearing application while utilizations of natural fibres are more to serve non-load bearing applications. As for natural fibres, even though they possess lower mechanical properties than traditional fibres (high performance fibres), for some type of natural fibres, their young's modulus range can be considered high. For instance, young's modulus of jute, flax, hemp and ramie are within the range of aramid and carbon. Therefore, they are presumably can be used to replace traditional performance fibres in some of the application which need for similar young's modulus (Dittenber & GangaRao, 2012; Koronis, Silva, & Fontul, 2013; Schuh & Gayer, 1997; Ticoala, Aravinthan, & Cardona, 2010).

Application of textile fibres embedded in polymer has long ago been established and there are many workers worked and still working on it. Akonda, Lawrence, and Weager (2012) used short recycled carbon fibres embedded in polypropylene thermoplastic matrix. Their composites possess high tensile and flexural strength, which were 160 and 154 MPa respectively, and this is good enough to be used as low cost material for much non-structural application. Bao, Liang, and Tjong (2012) worked also on short carbon fibre to reinforced polymer to investigate its fracture behaviour.Serna Moreno, Martínez Vicente, and López Cela (2013) fabricated a composite from chopped glass and polyester resin to study its failure strain and stress fields under biaxial loading. From this study, they came out with several failure models, which are taken as a reference. Employing pre-peg and vacuum bagging, Choi and Lee (2013) used short aramid fibres to reinforced carbon/epoxy composite to find a cheaper composite manufacturing process while Sun, Hu, Sun, and Chen (2013) used short aramid reinforced carbon-fibre aluminium foam sandwich to study the energy absorptions and peak loads sandwich beam. It is clear, that even with the short/chopped of high performance fibre, the workers' intention is to use them in medium and high performance applications.

Due to world population awareness on the environmental issues, there is an interest of research which focusing on the developing, creating and innovating eco-friendly materials. Natural textile fibres offer a good opportunity to be used as reinforcements in composite materials. Several natural textile fibres such as cotton, wool and silk are established for producing garment and apparel, thus, the usage of these fibres as composite reinforcement is minimal. However, there are numbers of publication on using them or their wastes in composite/hybrid compote material and for respecting their role in textile garment and apparel, they are not going to be discussed in this paper (Alomayri, Shaikh, & Low, 2013; Aluigi, Vineis, Ceria, & Tonin, 2008;

Bajwa, Bajwa, Holt, Coffelt, & Nakayama, 2011; Bertini, Canetti, Patrucco, & Zoccola, 2013; Cheng, Lin, & Huang, 2011; Conzatti et al., 2013; Dobircau et al., 2009; Hardy & Scheibel, 2010; S.-J. Kim, Moon, Kim, & Ha, 2008; G. Li, Yu, Zhao, Li, & Li, 2003; J. Li et al., 2009; Mahdi, Mokhtar, Asari, Elfaki, & Abdullah, 2006; Paiva Júnior, de Carvalho, Fonseca, Monteiro, & d'Almeida, 2004; Prachayawarakorn, Sangnitidej, & Boonpasith, 2010; Reddy & Yang, 2009; Rockwood et al., 2011; Shubhra & Alam, 2011; Shubhra, Alam, & Beg, 2011; Sionkowska & Płanecka, 2013; Sutivisedsak, Cheng, Dowd, Selling, & Biswas, 2012; Yuan, Yao, Chen, Huang, & Shao, 2010; Zou, Reddy, & Yang, 2011).

Table 1. Mechanical and physical properties of natural fibres.

Fibre	Density (g/cm^3)	Tensile Strength (MPa)	Young's Modulus (GPa)	Elongation at Break (%)	Length (mm)	Diameter (μm)
Synthetic						
E-glass	2.5-2.59	2000 – 3500	70	2.5	-	-
Aramid	1.4	3000 – 3150	63.0 – 67.0	3.3 – 3.7	-	-
Carbon	1.4	4000	230.0 – 240.0	1.4 – 1.8	-	-
Natural						
Bamboo	0.6–1.1	140–800	11–32	2.5-3.7	1.5-4	25-40
Jute	1.3-1.49	320–800	8-78	1.5–1.8	1.5-200	20-200
Kenaf	1.4	223-930	14.5-53	1.5-2.7	-	-
Flax	1.4-1.5	345–2000	27.6-103	1.2–3.3	5-900	12-600
Sisal	1.33-1.5	363–700	9.0–38	2.0–7.0	900	8-200
Hemp	1.4-1.5	270-900	23.5-90	1.0-3.5	5-55	25-500
Coir	1.15-1.46	95-230	2.8–6	15-51.4	20-150	10-460
Ramie	1.0-1.55	400-1000	24.5-128	1.2-4.0	900-1200	20-80
Abaca	1.5	400-980	6.2-20	1-10	-	-
Baggase	1.25	222-290	17-27.1	1.1	10-300	10-34
Cotton	1.5 – 1.6	287 – 800	5.5 – 12.6	3.0 – 10.0	10-60	10-45

More commercially natural fibres used for composite material are flax, jute, hemp and ramie which have traditionally taken a secondary role in terms of consumption, functional and technical requirements. Barkoula, Garkhail, and Peijs (2010) worked on the utilization of flax fibre to reinforce polyhydroxybutyrate (PBH) employing injection moulding to investigate how the fibre and copolymer hydroxyvalerate (HV) would affect the mechanical properties of fabricated material. Bodros, Pillin, Montrelay, and Baley (2007) used flax fibre as a reinforcement for Mater-Bi®, Bionolle PBS, Ecoflex PBAT, polylactic acid (PLA), L-polylactide acid (PLLA) and polyhydroxybutyrate (PHB) using film stacking method to study the best fibre loading for the composite. Ouagne, Bizet, Baley, and Bréard (2010), had tried to refine the film stacking fabrication method by using flax reinforced PLLA as his products. He studied the parameters involved in this processing such as temperature, time, compressibility and permeability.

Ma and Joo (2011) studied on the effect of different fabrication conditions, such as fibre content, processing temperatures and alkali treatment on the mechanical properties and structure of jute fibre reinforced PLA using the film-stacking method. Goriparthi, Suman, and Mohan Rao (2012) also working with jute fibre to reinforce PLA but their focus was to improve the adhesion of jute fibre by surface modification using alkali, permanganate, peroxide and silane treatments. Reddy and Yang (2011) developed biodegradable composite using jute fibre and soyprotein using water without using any chemical as plasticizer using prepeg method to produce their composite. Many researches have been conducted by using sisal fibre as the reinforcement for biodegradable composites (Alvarez & Vazquez, 2004; Cyras, Vallo, Kenny, & Vazquez, 2004; Mishra, Tripathy, Misra, Mohanty, & Nayak, 2002). There are also a number of reports that focus on using one type of fibre such as hemp (Hu & Lim, 2007; Lopez et al., 2012), ramie (D. Chen, Li, & Ren, 2010), silk (Yuan et al., 2010), coir (Nam, Ogihara, Tung, & Kobayashi, 2011), kenaf (Ibrahim, Yunus, Othman, Abdan, & Hadithon, 2010), baggase (Cao, Shibata, & Fukumoto, 2006), flax (Ouagne et al., 2010) and bamboo (Huang & Netravali, 2009; Shih, Huang, & Chen, 2010).

Utilization of textile fibres in composite material has long been established. However, even utilization of high performance fibre is meant for medium load bearing. Even there is research used this high performance in high performance application, the distribution and contribution of this high performance fibre is just small. More so if the natural fibres use in composite material, it is usually catered for the low and medium load bearing application. A factor that could lead to this scenario is because the dispersion and distribution of fibre in composite material. The method of fabrication usually does not take into account the alignment of fibre which the fibres are not interconnected. It is also difficult to control the uniformity of fibres' distribution, which could lead a failure when a place with less fibre is subjected to any destruction force. There are still researches carried out to improve the properties of composite material reinforced with fibre forms so it can be used in many applications.

Yarns

Usual fabrication method of applying fibre in the form of yarn is filament winding. This process is primarily used to produce hollow, generally circular or oval sectioned composites such as pipes and tanks. For this purpose of fabrication, thermoset resin like polyester and epoxy is preferred.

Kaddour, Al-Salehi, Al-Hassani, and Hinton (1996), studied the burst strength of thin filament wound with 75º angle ply using aramid yarns to reinforced epoxy resin as subject matter, while Rousseau, Perreux, and Verdière (1999) investigated the influence of winding patters on the damage behaviour of filament wound pipes. W. Chen et al. (2007) worked on the new epoxy to investigate its adhesive properties. Using filament winding fabrication method, carbon fibre was selected to reinforce this new epoxy system. It is found that the interfacial properties in this composite system improved as well as its toughness. Arvin and Bakis (2006) studied the optimal design of press-fitted, cylindrical, filament wound composite flywheel rotor for producing composite. Utilizing carbon yarns and epoxy resin, they found that by using 5 – 8 press-fitted carbon/epoxy rings and tip speeds of 800-900 ms^{-1} they established the specific energies of 40-50 W.h/kg. He feels that this filament winding is quite costly method, Abdalla et al. (2007) in his work tried to design a low filament winding machine. His new fabricated machine, a lathe-type and wet winding method were used in the design of the

machine and this machine able to produce glass, carbon and aramid yarns/tows reinforced polymer.

Recent works have also shown the utilization of natural textile yarn as reinforcement in composite material.. Huang and Netravali (2007) in their research to fabricate environment-friendly 'green' composite used flax yarn to reinforced soy protein concentrate. During composite fabrication, they used metal frame to wind the hemp yarns and applied small tension to minimize the yarn shrinkage and misalignment during the drying of resin. J. T. Kim and Netravali (2011) used similar method of fabrication with Huang and Netravali (2007). However, they used hemp yarn to reinforced soy protein concentrate resin processed at various pH values, and they intended to study the effect of pH on mechanical and interfacial properties. George et al. (2012) investigated the fabrication process of jute yarn reinforced, bidirectional thermoplastic commingled composite for treated and untreated samples. Using polypropylene yarn as a resin, jute yarn were wound onto a metal plate in a specific layer pattern using a fibre winding machine specifically designed for commingling. This commingled jute and polypropylene were then pressed under hot presser in different parameters. Even though, these workers using a different method of composite fabrication when dealing with yarns and tows, their method principle is quite similar with filament winding. In both method, yarns have to be straight and this could only be achieved by applying small tension on it. This is important to make sure the uniformity of fibres/yarns distribution and density in the composite material.

Other methods than filament winding can also be used for yarn form reinforcement which believably needs some alteration and assumption. For example, Shah, Schubel, Clifford, and Licence (2013) fabricated his sample by employing vacuum infusion to produce composite made of jute, hemp and flax yarns. Using unsaturated polyester resin as a matrix, he studied the fatigue data on natural fibre composites and this is an important parameter which limits their prospective use in fatigue critical components. From this study, he established the fatigue data of fabricate materials and compared with the e-glass/polyester composites. Utilization of textile yarn gives more control of the properties of composite materials. This is because the scattered fibres are combined and aligned in a group with or without twist given. Nevertheless, there is less of work considering the effect of yarn parameters such as yarn size, yarn twist and twist angle on composite material. Working with these parameters will gives us more input and knowledge on how the composite will react because the yarn properties change with the change of its parameters.

The existence of yarn form in reinforcement is very useful to manufacture circular and hollow material. However, the well-known and establish method of fabrication for employing this yarn limited only for filament winding in which the yarn will be wound onto a shape core before the resin is applied on it. Based on the discussion above, some other works try to use other methods of fabrication such as by winding this yarn onto the metal plate. However, this method is basically similar in principle with filament winding. Therefore, some works are needed to vary the processing method of composite material using textile natural yarn (even for high performance yarn) in order to enhance the potential of this kind form of reinforcement to its optimum performances.

Fabric

Scardino (1989) divided the textile structures or reinforcement forms into four categories; discontinuous chopped fibres, continuous filament yarns, simple fabrics (2-D) and advanced fabrics (3-D) systems. An interesting part to be discussed here is the usage of simple fabric and advanced fabric systems as reinforcement in composite materials. These kinds of reinforcement are preferably used by manufacturer or researcher due to it physical which easy to handle. Figure 5 shows some common textile fabric used as composite reinforcement (Lomov et al., 2005). Producing simple or 2-D fabrics of high performance fibres is commonly used either interlacing (weaving) or interloping (knitting) method. In weaving method, the fabric consists of interlacement of warp (length wise) and weft yarn (width wise). Knitted fabric consists of interloping yarns either in weft (weft knitting) or warp direction (warp knitting) directions.

There are a lot works done on using 2-D fabrics as reinforcement in composite material either for thermoset or thermoplastic resin. High performance fabrics usually dominate high performance application. Choi, Kim, Lee, and Seo (2011) used aramid fabric to replace E-glass for low-observable radomes since it has lower dielectric constant and higher strength than E-glass and it should have better electromagnetic wave transmission characteristics. This material is usually used in aircrafts, warships and missiles functioning to protect the radar antennas. In his work low-observable radome was constructed with a sandwich construction composed of aramid/epoxy. The mechanical properties were measured by means of 3-point bending test and then compared to those of the conventional which made of e-glass/epoxy.

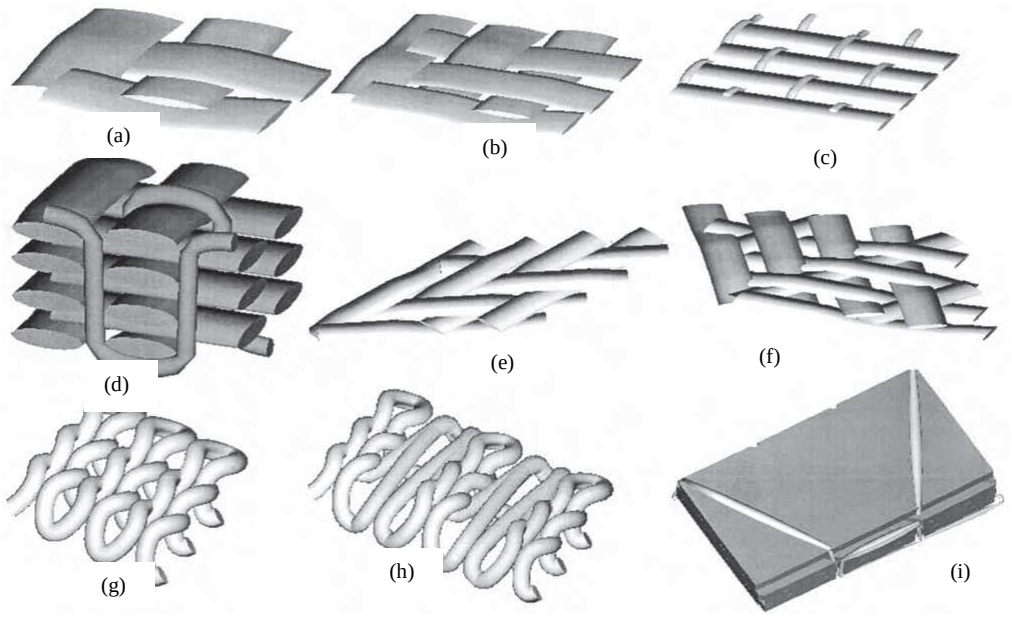


Figure 5. Structure of textile fabric; (a-c) 2-D woven fabrics, (d) 3-D fabric, (e-f) braided fabrics, (g-h) knitted fabric and (i) multiaxial multiply warp-knitted fabrics (Lomov et al., 2005).

Aramid fabric is very well known in protective industries due to its high strength and high impact resistance. It is also light and suitable to be used as lightweight ballistic protection or soft armour. Carrillo, Gamboa, Flores-Johnson, and Gonzalez-Chi (2012) in his work used aramid fabric reinforced polypropylene in composite laminate form as

a new material for soft armour. He found that the thermoplastic polypropylene increases the ballistic performance of composite laminates. This is due to the existence of polypropylene which has good elongation properties when it subjected to tensile force. This enables Carrillo's material to have additional energy to absorbance hence improve its performance. In another work, Othman and Hassan (2013) investigate the role of aramid layer in soft armour emphasized on the different direction (0º and 90º) on fabric alignment. He found that the cross-ply aramid laminates could dissipate the impact energy up to 17% and also have the capability to stop the projectile at the minimum layer compared to the aramid which layered in one direction. There is a lot more researches in his area, yet there is still no assessment on the internal injury for the wearer. Aktaş, Aktaş, and Turan (2013) study the effect of stacking method of woven/knitted fabric of glass /epoxy hybrid composites on its impact behaviour while Russo, Acierno, Simeoli, Iannace, and Sorrentino () studied on the flexural and impact response of woven glass fabric reinforced polypropylene employing stacking film method fabrication. Glass fabric was also been used in construction fields. Gopinath, Iyer, Gettu, Palani, and Murthy (2011) used glass fabric to study its confinement effect when bonded with cementitious and organic binders. It was found that the existence of glass fabric enhances the load carrying capacity and ductility for both bonding materials (cementitious and organic binders). This material could be used as a confining system for retrofitting applications.

Fei, Li, Huang, and Fu (2012) studied the effect of phenolic resin on friction and wear performance of the composites using four kinds of carbon fabric using impregnation technique. His analysis has very close relation to the resin content of the composite fabricated and he found that the dynamic friction coefficient decreased with the increase of resin content, but the friction coefficient ratio increased. The sample with 25 wt% resin content possessed the best wear resistance due to the moderated combination between the carbon fibres and the matrix and good friction surface formation. This is one of the researches to enhance the performance of the carbon composite especially in automotive industry since this material has been used widely in a clutch system.

In sports fields, application of carbon fabric reinforced polymer had been studied by Ullah, Harland, and Silberschmidt (2013). This type of material is always exposed to various modes of damage and fracture under impact bending loads. Therefore, they studied these failure modes using experimental material characterization and numerical simulations and managed to developed numerical models which capable of simulate all damage mechanisms as well as their subsequent interaction observed. This is good research and it should be expanded to other high performance materials such as glass and aramid which could lead to very interesting results. Application of 3-D fabric is quite common for synthetic fibre especially in high performance fibre and this structure with natural fibre is almost none may be due to high cost on fabricating 3-D fabrics. Weaving, warp knitting, braiding, nonwoven and other specially modified techniques can manufacture a fabric with multi-plane structures. Woven fabric in the form of 3-D architecture employs multilayer and pile structures. However, it cannot produce thick structures as its shedding limits the number of layers possible. Thick structures are usually made using braiding technique, but it is limited in width. Knitted structures are normally made using warp knitting, but again, it is limited in thickness (Lomov, Verpoest & Robitaille 2005).

3-D fabric usually used in structural application, and it offers cost advantages to replace other isotropic which is usually more expensive. Interest in research and

application of thick 3-D orthogonal weave reinforcement is fast growing. Bogdanovich et al. (2011) studied to enhance the performance of 3-D orthogonal woven e-glass composite's joint. A comprehensive experimental study was performed to determine the strength of several co-cured and adhesively bonded joints of composite panels. He found that stitching and stapling dry preforms resulted in a significant increase of the co-cured single-lap joint strength and tapering strap ends to as a small angle as possible was found to be the most effective method of increasing break force of double butt-strap bonded joints.

Carvelli, Pazmino, Lomov, and Verpoest (2012) worked on deformability a single-ply E-glass non-crimp 3D orthogonal woven reinforcement by comparing its properties to 2-D fabrics obtained from several deformation test modes while Cherif, Krzywinski, Lin, Schulz, and Haasemann (2013) suggested new process chain for producing complex 2-D/3-D weft knitted fabrics using glass yarn for thermoplastic composite applications. By using flatbed knitting that usually used for producing weft knitted fabric, he managed to produce near-net-shape or fully fashion multilayer weft knitted fabrics. This is very interesting work, since; the shapes of composite are limited and follow the available 2-D planar material. Using this knitting method, the reinforcement could be designed according to shape that we want seamlessly and this could result to good properties of composites.

Application of natural fibre (except those that are used for garment and apparel) in fabric form is also well established aligned with high performance fabric. However, their utilization is limit for non/low load bearing and semi structural application. There are many researches done on using natural fabric as composite reinforcement. However, there is a limit of choices on natural fabric because not all types of fibre can be converted into fabrics, especially in woven and knitted fabric. In order to convert a natural fibre into fabric, the diameter and length of fibre play important roles. This is because most of the weaving and knitting machine cannot process a fibre that too coarse and too short. Even it can be done, the method could not offer cost advantage and this remain a challenge for fabric manufacturers. Another way on converting natural fibre into fabric is by turn it into non-woven fabrics. A famous method on fabricating this is by using needle punch machine. A product from this method also calls fleece or felt but the real problem with this method is on how to make sure the homogeneity of fibre distributions because the uneven distribution will results to uneven mechanical properties of fabric and to some extent, to composite properties as well.

Jute fabric was used by Huang and Netravali (2007) to reinforced soy protein concentrate resin in their efforts to innovate fully environment-friendly, sustainable and biodegradable green composite. Their green composite exhibits excellent flexural properties in warp and weft directions. Unlike Huang and Netravali, Behera, Avancha, Basak, Sen, and Adhikari (2012) used jute felt o reinforced soy milk based resin and he found that composite having 60 % jute felt possessed the best mechanical properties and the novelty of his work is the resin preparation. Jawaid, Abdul Khalil, Hassan, Dungani, and Hadiyane (2013), by employing hand lay-up, prepared a composite made of epoxy resin reinforced with hybrid jute fabric and oil palm fibre and he expected this material to have a good potential in automobiles and building industry in near future. Barkoula et al. (2010) focused on short flax fabric reinforced composites based on polyhydroxybutyrate (PHB) and its copolymer with hydroxyvalerate (HV) employing compression moulding to study its biodegradability.

Hemp is another type of fibre that can be converted into fabrics. It popularity is getting higher lately due to its availability in different sizes and structures. Song et al.

(2012) examined the physical behaviour of hemp/poly(lactic acid) (PLA) composites, particularly the thermal properties and viscoelastic behaviour. He used twill and plain woven hemp fabrics as reinforcements by stacking film method. The twill structure was found to be suitable for reinforcing a PLA resin with higher impact strength and better mechanical properties than the plain woven. Hemp fabrics were also been used by Kabir, Wang, Lau, Cardona, and Aravinthan (2012) to form composite skins while short hemp fibres with polyester as a core for making composite sandwich structures, while Christian and Billington (2012) fabricated hemp fabric composite to reinforce poly(b-hydroxybutyrate) biopolymer in order to evaluate its feasibility for construction applications as replacements for wood or petroleum based composites. Michel and Billington (2012) claimed that biobased polymer composites have been shown to have suitable initial specific strength and stiffness for use in commercial applications yet the long-term performance of these materials under variable environmental conditions is largely unknown. Therefore, using fabricated composite made of hemp fabric poly-hydroxybutyrate (PHB) they performed accelerated weathering test.

There are a lot of work on using natural fabrics that have been published in many journals and academic writings. The work that was discussed above is just a small part in natural fabric composites. Nevertheless, there is a limit of work which considering the fabric parameters when dealing with natural fabrics such as, fabric density, fabric structure, arial density etc. These factors are very important to determine as the fabric properties will change with the changes of its parameter. Basically, fabric parameters are used to determine fabric properties which relate to its fibre direction, orientation as well as the fibre mass. Therefore, a work on considering these factors is necessary in order to understand their relationship with composite properties.

CONCLUSION

The definition of textile gives the understanding of the types and forms of textile materials. This is very important to understand and acknowledge the contribution of textile material as composite reinforcement. Even for fibre, yarn and fabric, the research is still carried out to enhance its composite material thus suit various applications. It is good to highlight several matters regarding to usage of textile material as reinforcement. The application of composite material reinforced with textile fibres forms basically limit to low and medium load bearing applications. Thus, research emphasized to improve the fibre reinforced composite to suit the purpose of application should be and will be continued. Whereas yarn reinforcement gives more control on the composite materials due to the fibres is aligned in a yarn regardless the twist is given or not. However, the established method of fabrication limits the usage of yarn and there is a need of fabrication process using this kind of textile material other than filament winding to ensure the varieties of end product of yarn reinforced composite. Utilization of textile fabric in composite as reinforcement is well recognized for high performance fabric so it is with natural fabric. Nonetheless, there is a limit of work considering fabric properties or parameters when characterize its composite to understand the fabric contribution in composite material.

On top of all research using natural textile materials, apparently, there is less research done on the assessment of the product life cycle for natural textile materials reinforced composites. This is important to put all the product concepts into the perspective in order to determine the product's survival and suitability for particular/designed purposes. Even though there are hundreds or thousands of work, as

far as anisotropic material is concern, research and development of this kind of material will keep continuing due to variation of possibilities when utilizing textile reinforcement forms, matrices and applications.

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GENETIC SUSCEPTIBILITY TO NON-HODGKIN'S LYMPHOMA: FOXP1 AND FCRL3

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ABSTRACT

Non-Hodgkin's Lymphoma (NHL) is a group of malignancies of white blood cells that typically result in solid tumours. NHL is the fifth most common cancer type, with an incidence of approximately 19 cases per 100,000 people. NHL is also the sixth most common cause of cancer death in Australia, which has comparable rates of incidence and mortality to other developed nations. In this retrospective case-control study, the aims are the attempt to link a pre-existing phenomenon; genetic variation of both *FOXP1* and *FCRL3* gene with a present outcome of diagnosis of NHL and to observe the utility of different genotyping methods which are the Restriction Fragment Length Polymorphism (RFLP) and secondly by using High Resolution Melt (HRM). The research will provide information that may be useful in predicting who is at high risk for developing lymphoma and how to develop new treatments in the near future.

Keywords: Non-Hodgkin's lymphoma; *FOXP1; FCRL3;* restriction fragment length polymorphism; high resolution melt.

INTRODUCTION

There are many components of cells in the blood, namely the red and white blood cells along with many more. This research is a study on a type of blood cancer, specifically the one originating from the white blood cells, and more precisely the cells called lymphocytes which are involved in causing a disease called lymphoma. This project will focus on determining how genetic factors can influence the development of this cancer of the white blood cells and the solid tumours it produces. Variations in genes that have been previously implicated in lymphoma development will be examined closely in both lymphoma patients and healthy individuals. This permits an investigation of whether these variations are involved in the genesis of lymphoma, or in the development of specific characteristics of the disease. Laboratory tests will be performed on the genetic material extracted from the blood of the participants (patients and healthy volunteers). It is necessary to perform the same tests in the same way on DNA from healthy volunteers who do not have lymphoma so that we can compare the healthy DNA to the cancerous DNA and detect any important differences. In the near future, it is hoped that medical research studies on this particular disease will be able to diagnose more precisely the types of lymphoma and also the survival and outcome of the patient. Furthermore, this particular research will provide information that may be useful in predicting who is at high risk for developing lymphoma so that potential new cures can be formulated.

LITERATURE REVIEW

Non-Hodgkin's Lymphoma (NHL) is a group of malignancies of white blood cells that typically result in solid tumours. The most common entities of NHL are diffuse large B-cell lymphoma (DLBCL) 31%, follicular lymphoma (FL) 22% and B-cell chronic lymphocytic leukemia (B-CLL) 7% , which together account for 60% of all cases (Friedberg and Rich, 2011). DLBCL is an aggressive lymphoma and both FL and B-CLL are indolent. The linked aetiology of these malignancies is highlighted by the capacity of FL and B-CLL to undergo transformation to an aggressive DLBCL-like disease. This common endpoint has led to the search for common genetic factors that may influence the development of the disease.

Prevalence of the Disorder

Non-Hodgkin's Lymphoma (NHL) is a heterogeneous group of diseases with different types of behaviour, prognosis and epidemiology. A few risk factors for selected types of NHL have been identified, including conditions linked to the immune system, human immunodeficiency virus (HIV), hepatitis C virus and occupational or environmental and exposure to certain carcinogens. However, despite this knowledge, the causes of most NHLs remain largely unknown. During the past decades, the incidence of the most common Non-Hodgkin's Lymphomas has also increased dramatically worldwide. The disease does not only affect adults. The French National Registry of Childhood Leukaemia and Lymphoma (NRCL), which covers the population aged less than 15 years for all childhood haematopoietic tumours reported that there were 5757 cases of leukaemia, lymphoma and myelodysplastic syndrome with an average of 2.5 sources per case from 1990 to 1999. The age-standardized incidence rates per million per year were 43.1 for leukaemia (34.3 for acute lymphoblastic leukaemia, 7.1 for acute myeloblastic leukaemia, 0.6 for chronic myeloid leukaemia and 0.5 for chronic myelomonocytic leukaemia), 8.9 for Non-Hodgkin's Lymphomas and 6.7 for Hodgkin's disease (Clavel et al., 2004).

In Egypt, NHL is the fifth most common cancer. The general incidence rate was 5.90 in 1995 and reached 8.99 in 2004, with a peak 9.40 in the year 2002. The male incidence of Non-Hodgkin's Lymphoma demonstrated an obvious rise from 1995 to 1998, with a slowing from 1999 to 2002, followed by another evident rise from 2003. Women showed an increase in incidence rates from 1995 to 2000, then a decline afterwards, till 2004. As regards the population from 15 to 60 years old, there was a rise through the period from 1994 to 1999, then a drop from 2000 to 2004. In the elderly group, the incidence rate was doubled during the 10 years from 1995 to 2004, going from 13.36/100 000 in 1995 to 26.65 in 2004. In general, the incidence of Non-Hodgkin's Lymphoma increased steadily from 1995 to 2004 in Alexandria, particularly in the elderly population. (Abdel-Fattah and Yassine, 2006). A study conducted in the same population was undertaken to study different prognostic factors of aggressive non-Hodgkin's lymphoma and evaluate the utility of the International Prognostic Index (IPI) in predicting disease response, overall survival and relapse free survival. One result of the study was the observation that aggressive NHL treated with chemotherapy did not have satisfactory outcomes. The researchers suggested that utilizing IPI in all patients with aggressive lymphoma would provide better understanding of the prognosis of patients and tailoring the treatment (Koheil, Mohamed, and Mahmoud, 2009).

The incidence of Non-Hodgkin's Lymphoma increased by more than 80% between 1975 and 1991 in the United States, representing one of the largest increases of any cancer. While the overall NHL incidence rates began to stabilize in the late 1990s. Part of the overall steep increase in NHL incidence over the last several decades is due to human immunodeficiency virus (HIV) infection, although the incidence of NHL has been increasing irrespective of HIV status. Other pathogenic associations with NHL include viruses and bacteria (eg, human T-cell lymphotropic virus type 1, human herpesvirus 8, hepatitis C and *Helicobacter pylori* and medications that cause extreme immunodeficiency (Evens Am, 2008). Attenuation of the epidemic increase in NHL incidence has recently been reported in the USA and Nordic European countries. After two decades of steadily increasing NHL, a study by (Marcos-Gragera et al., 2010) sought to ascertain whether a similar stabilisation might have taken place in Spain in recent years. NHL cases were drawn from 13 population-based Spanish cancer registries with a record of at least 10 years of uninterrupted registration during the period 1975-2004. Overall and age-specific changes in incidence rates were evaluated using change-point Poisson models, which allow for accurate detection and estimation of trend changes. In Spain, NHL incidence levelled off in 1996 after a sharp increase during the 1970s and 1980s. This stabilisation is, partially at least, linked to the decrease in incidence of AIDS-related lymphomas among young adults.

Diagnosis and Treatment of NHL

The haematological malignancy NHL presents with various clinical and molecular features that a physician will use to assist in their diagnosis. The traditional methods include excision lymph node biopsy by fine needle aspiration or bone marrow aspiration. Physicians will also use imaging studies and clinical laboratory methods. The up-to-date ways to conduct diagnosis are the molecular methods such as FISH, PCR, and DNA microarrays which can provide a more precise method of analysis. Although the lymph node biopsy remains the gold standard, molecular analysis is an increasingly valuable tool to assist physicians in diagnosing NHL (Andrade, 2007) and that is why biomedical researchers are working to discover the best way to diagnose the disease preferably at the earliest stage. The earlier the onset could be detected, the better it is for disease management. Non-Hodgkin's Lymphoma includes several lymphoproliferative malignant diseases with different clinical and histological appearances which can present in various ways and be difficult to diagnose where most cases arise extranodally and present special problems. Developments in cytotoxic chemotherapy have led to good long-term survival prospects for aggressive lymphoma. Novel approaches including monoclonal antibody therapy also offers promise for indolent lymphoma (Evans and Hancock, 2003).

Before better treatments were discovered, NHL patients had to go through a difficult treatment which is toxic conventional chemotherapy regimens. This is now considered inappropriate as the treatment does not improve overall survival and the patients have adverse effects. Fortunately, things have changed after a new drug was invented called Rituximab. It is a human-mouse chimeric monoclonal antibody that has shown efficacy in patients with NHL. The benign tolerability profile of Rituximab makes it a suitable candidate for first-line treatment of follicular NHL patients with a low tumour burden. In a trial of 49 patients, 73% achieved a clinical response (26% complete response) with Rituximab treatment. Molecular studies showed that 57% of patients achieved molecular remission (clearance of the bcl-2 molecular translocation

from the blood, evaluated by polymerase chain reaction), 62% of these remaining bcl-2 translocation free- for at least 1 year. There was a good correlation between molecular and clinical responses, with patients failing to achieve a molecular response at higher risk of disease progression. Rituximab monotherapy is therefore an effective and well-tolerated treatment for patients with low-grade lymphoma and a low tumor burden (Solal-Céligny, 2001).

The current standard therapy for patients with diffuse large B-cell lymphoma (DLBCL) is rituximab plus cyclophosphamide, doxorubicin, vincristine, and prednisone (R-CHOP). Consolidative radiation therapy (RT) in the setting of R-CHOP chemotherapy is used as well, but its outcomes are not well reported. One study showed significant improvements in overall survival and progression free survival among patients who received consolidation RT after R-CHOP chemotherapy for diffuse large B-cell lymphoma (DLBCL) (Phan J et al., 2010). There are useful dietary guidelines which are strictly recommended for post treatment lymphoma patients. These emphasize making nutritional choices for daily consumption to live a better life and include to maintain weight within normal range, stay active by getting the equivalent of 30 minutes of walking per day, consume calorie-dense foods sparingly and eat at least 5 portions of non-starchy vegetables and fruits per day (Lymphoma Research Foundation, 2013).

The molecular pathogenesis of NHL is very broad and complex as there is a range of subtypes that differ in their clinical and pathological manifestations. This particular study will focus on genetic susceptibility of Non-Hodgkin's Lymphoma. Genetic susceptibility refers to defining an increased likelihood or chance of developing a particular disease. It is due to the presence of one or more gene variations, mutations and/or a family history that indicates an increased risk of the disease. It is also called genetic predisposition (NCI Dictionary of Genetics Terms, 2013). To create a genetic test that will screen for a disease in which the disease-causing gene has already been identified, scientists collect blood samples from a group of individuals affected by the disease and analyze their DNA for Single Nucleotide Polymorphism (SNP) patterns. A polymorphism is a common mutation or variation in the DNA. It is typically defined as having an allele frequency of at least 1%. All genes occur in pairs, except on the sex chromosomes, when X chromosomes are paired with Y chromosomes in males; thus a polymorphism with an allele frequency of 1% would be found in about 2% of the population, with most carriers having one copy of the polymorphism and one copy of the normal allele (NCI Dictionary of Genetics Terms, 2013). Researchers compare these patterns from the population of disease patients to patterns obtained by analyzing the DNA from a group of individuals unaffected by the disease with closely matched characteristics to the disease population. If the variant is associated with the development of the disease or provides resistance to it, the proportions of different genotypes in this population will vary.

FOXP1

The FOXP1 gene is located at chromosome 3p14.1and this locus is frequently targeted by amplification in haematological malignancies. The FOXP1 transcription factor is part of the FOXP subfamily of transcriptional repressors (FOXP1-4), which are characterised by the presence of the winged helix/forkhead DNA binding domain (Banham et al., 2001). FOXP1 has been implicated in the molecular subtyping of the advanced DLBCL lymphoma. Molecular analysis of DLBCL revealed at least two

subtypes characterised as ABC DLBCL and GCB DLBCL (Alizadeh et al., 2000), with significantly different overall survival. The results of the molecular analysis identified FOXP1 as a marker for the ABC DLBCL subtype, though further studies observed variable prognostic significance of this marker (Choi et al., 2009; Hans et al., 2004). However, the over expression of FOXP1 is associated with poor survival of DLBCL patients, indicating that it is involved in the regulation of several factors important to the disease development (Banham et al., 2005) (Barrans, Fenton, Banham, Owen, and Jack, 2004).

FOXP1 and the Cyclin E gene were evaluated in primary central nervous system lymphoma (PCNSL) of immunocompetent patients on prognostic significance. The clinical outcome in patients with primary central nervous lymphoma (PCNSL) is variable and poorly predictable. Clinical data of 71 patients with newly diagnosed PCNSL from 2002 to 2007 was analyzed retrospectively. *FOXP1* expression might be an important prognostic factor for shorter overall survival (OS) (P = 0.065). Cyclin E expression was found to be an independent prognostic factor and *FOXP1* expression was a possible prognostic factor for poor clinical outcome in patients with PCNSL (LShen, BB Chen, Z Chen, XP Xu, and GW Lin, 2012). Another study investigated the association of clinical features and immune markers with prognosis of patients with PCNSL. One hundred and fifteen newly diagnosed PCNSL patients at the study institution were considered eligible for this study. Clinical characteristics and biochemical assay data were collected. Immunohistochemical staining of Cyclin D3, Cyclin E, *FOXP1*, and LMO2 were performed. Diffuse large B-cell lymphoma composed of 96.5% of the cases. By contrast to the result from Chen *et al.*, expression of *FOXP1*was not found to be related to patient survival. Expression of Cyclin E, large tumour size, and high serum globulin were found to be independent prognostic factors for PCNSL in this study (Chen et al., 2013).

The clinical significance of *FOXP1* and p65 expression in diffuse large B-cell lymphoma (DLBCL) has also been studied. Immunohistochemistry was performed to determine the expression of FOXP1 and p65 protein in 92 DLBCL tissues and analyze their correlations with clinicopathological features or prognosis of patients. Both FOXP1 and p65 protein expression were associated with the non-germinal centre b-cell-like phenotype (p=0.001 or 0.000). The Kaplan-Meier survival curves showed that both FOXP1 and p65 expression were associated with poor survival of patients. Meanwhile, FOXP1+/p65+ subgroup had the worst progression free survival (p=0.012) and OS (p=0.030), whereas the FOXP1-/p65- subgroup had the best prognosis. Thus, immunohistochemical assessment of both FOXP1 and p65 status in DLBCL tissues may be a valuable approach for predicting the survival of DLBCL patients (Hu, Wang, Wang, Sun, and Chen, 2013).

FCRL3

Fc receptor-like 3 (FCRL3) is a type I transmembrane protein and member of the FCRL family (FCRL1-6), and located at chromosome 1q21-q22. The expression of this gene commonly occurs in lymphoid organs, where it is restricted to CD19+ B cells within germinal centres and compartmentalised to the centrocyte zone (Chistiakov and Chistiakov, 2007). Although the specific role of FCRL3 in NHL has not been characterised, the FCRL locus (encoding FCRL1-5) is targeted by the 1q21 translocation in 17-20% of FL and DLBCL, 27-38% of Burkitt's lymphoma and 20-31% multiple myeloma cases (Hatzivassiliou et al., 2001; Miller et al., 2002).

There has been increasing evidence of shared genetic markers between NHL and autoimmune diseases such as systemic lupus erythematosus (SLE), Sjögren syndrome (SS) and rheumatoid arthritis (RA) (Conde et al., 2011). Patient history of autoimmune disease is a strong independent risk factor for lymphoma development, with reported risk estimates for the development of NHL between 1.5-8.7 (Grulich et al., 2007; Martin et al., 2009; Smedby et al., 2008). Interestingly, there is some evidence that the FOXP family influences the expression of the FCRL family. Fc receptor-like 3 (*FCRL3*) is a cell surface protein homologous to Fc receptors. A study by (Satoshi, Tomoko, and Ira, 2009) suggests that the $FCRL3^{+}$ subset of human nTreg cells identified in this study arise *in vivo,* and Foxp3 expression alone is involved with, but not sufficient to induce *FCRL3* expression. *FCRL3* may be involved in human specific mechanisms to control the generation of nTreg cells.

RESEARCH DESIGN

Study Design

A suitable approach for this study is to follow a case-control observational design involving quantitative measurement of independent variables in order to determine if an association exists with a dependent variable. In this retrospective case-control study, the aim is the attempt to link a pre-existing phenomenon; genetic variation of both *FOXP1* and *FCRL3* gene with a present outcome of diagnosis of Non-Hodgkin's Lymphoma (NHL)in a group of people who are affected (cases) and another group of people who are not affected (healthy controls). A comparison will be made between cases and controls by examining whether the dependent variable is correlated with one or both of the antecedent independent variables. Suitable controls will need to match the cases as much as possible in terms of extraneous variables that may affect disease presentation, such as age, gender and ethnicity.

Sampling

In the susceptibility aspect of this project, the genomic DNA taken from NHL sufferers will be examined as well as age, sex and ethnicity matched healthy individuals. These genomic DNA samples have been recruited in collaboration with clinicians at the Royal Brisbane and Prince Charles Hospitals in Queensland, Australia. In order to minimise impact on patients and improve take-up rates for the project, the DNA for the research will be derived from saliva rather than blood. The current population for this project is 135 NHL patients and controls with associated tumour tissue and information regarding diagnosis and disease pathology for later analysis. Additional recruitment will take place forming up to 300 cases and controls for the research. Controls will be matched to cases in terms of age, gender and ethnicity, as these factors have been shown to affect the development of lymphomas. Thus both case and control populations will be identical as far as possible, other than their disease status. Where possible, participants will also contribute tissue taken from their tumours following surgery, so that genomic data from tumours and patients can be compared for additional analysis.

Methods

This research will utilise a case-control approach to identify polymorphisms that contribute to the risk of NHL development and pathology. The project will examine genetic polymorphisms in four candidate regions and genes that have been previously identified as potential targets for future research by whole genome techniques and will be genotyped using two different methods which are the Restriction Fragment Length Polymorphism (RFLP) and secondly by using High Resolution Melt (HRM). These methods allow multiple specific loci to be interrogated at relatively high throughput and low cost. Following genotyping, the data will be analysed to determine if any of the polymorphisms being interrogated are associated with NHL development, specific subtypes of the disease or other aspects of disease pathology. Both methods to be used in this research are based around polymerase chain reaction (PCR), which amplifies specific regions of target DNA. The extracted and purified DNA will be diluted for genotyping by PCR-RFLP (polymerase chain reaction – restriction fragment length polymorphism). Both genes with two different SNPs each will be used for this method.

Table 1. Primers and enzymes for each gene.

GENE	**SNPs**	**PRIMER**		**ENZYME**
		Forward	Reverse	
FOXP1	rs6549400	CTTGCTACACGGATGAGAGA	TGACCATTTGAGCTGTGGAAGA	NdeI
	rs11720523	ACAGGGAGAGGGAAGGAATGT	GGAGGGGGAAGTACAATGGC	BaeGI
FCRL3	rs3761959	TGCCTCTGTCCTTTGCTCTG	GCCTCCTCCGACTTTTTCAGT	AgeI
	rs10494316	TGAAGGAAGGATGGTGCTGT	GGAGGTTTACCATTCCCTAGTT	CviQI

Statistical Analysis

The accuracy of the genotype frequencies of the subjects will be checked using a Chi-square test against an ideal randomly mating population in accordance with Hardy-Weinberg equilibrium. P-values will be calculated where a value of $P < 0.05$ is considered statistically significant by comparing allele and genotype frequencies of each tested SNP- case versus control. Odds ratios (OR) and 95% confidence intervals (CI) adjusted for covariates (eg. age and sex) will be estimated using unconditional logistic regression analysis for each SNP. Power estimates suggest that if the SNPs confer at least a two-fold increase in relative risk of ($OR \geq 2$), the case and control groups of sample size n=250 each are of sufficient size to have ≥80% power to detect an association as statistically significant at the 0.05 level.

EXPECTED OUTCOME & CONCLUSION

The expected outcome of this research is to identify the single polymorphisms in two different genes which have been studied previously and found potentials associations with Non Hodgkin's Lymphoma. The research will provide information that may be useful in predicting who is at high risk for developing lymphoma and how to develop new treatments in the near future.

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OIL EXTRACTION FROM HETEROTROPHIC MICROALGAE BIOMASS: A PRELIMINARY STUDY

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ABSTRACT

Heterotrophic cultivation is an alternative of commonly used phototrophic microalgae cultivation, whereby microalgae assimilate organic carbon and accumulate lipids under nitrogen-limiting condition. However, successful microalgae cultivation is not just limited to the type of growth selected for lipids accumulation. It is important to ensure efficient lipids extraction for maximum lipids yield from algal biomass. This study aims to investigate effects of sample preparation by grinding, temperature (150 ℃) and static time (10 min) for microalgae oil extraction by Accelerated Solvent Extraction (ASE) which employs pressurized liquid extraction technique. Microalgae biomass from *Chlorella protothecoides* cultivated heterotrophically was extracted with chloroform:methanol (2:1 (*v/v*)) and different static cycles at temperature of 120 ℃ for 5 min. 4 static cycles resulted in higher oil extraction than 2 static cycles. The study was then followed by oil extraction with different parameters, namely ground sample, higher operating temperature and longer static time. All three parameters resulted on improved oil extraction. However ground sample gave yield to the highest oil extracted by ASE.

Keywords: Accelerated solvent extraction; microalgae; heterotroph; *Chlorella protothecoides*.

INTRODUCTION

The use of lipids from microalgae is not limited to biodiesel production, in fact it can also be applied in the manufacturing of health products such as DHA and EPA (Pyle et al., 2008). Conventionally, microalgae are grown through phototrophic cultivation for lipids production, which requires illumination and carbon dioxide (CO_2) for photosynthesis. Cultivating microalgae phototrophically in open ponds is advantageous in term of the use of freely available sunlight. However, there are some limitations for this type of cultivation due to weak light diffusion, vulnerability to contamination and changes in climate (Perez-Garcia et al., 2011). On the other hand, microalgae can also be grown in closed photobioreactors which may overcome these problems. However, it is expensive to operate and exhibits poor photosynthetic deficiency (Cerón-García et al., 2013). Heterotrophic cultivation has the potential to alleviate the limitations in photobioreactors, as heterotrophic microorganisms are independent of photosynthesis for growth and subsequently the need of light (Tabernero et al., 2012, Chen et al., 2011). Additionally, microalgae can also be grown heterotrophically in any organic substrate which may reduce installation and harvesting costs of growing microalgae.

Another crucial process in growing microalgae for lipids production is the extraction of lipids. The three most commonly used microalgae lipids extraction techniques frequently referred to as the Bligh and Dyer, Folch and Soxhlet extraction techniques. However, these extraction methods are inefficient as they consume a high amount of solvents for extended period of time (Poerschmann and Carlson, 2006). An alternative extraction method is pressurized liquid extraction (PLE), which involves solvent extraction at elevated temperatures under high pressures. Therefore, PLE technique improves the extraction efficiency when compared to room temperature extraction techniques such as the Bligh and Dyer and Folch extraction methods (Poerschmann and Carlson, 2006, Mustafa and Turner, 2011, Bligh and Dyer, 1959, Folch et al., 1957). In this study, oil will be extracted from dry samples of *Chlorella protothecoides* grown heterotrophically with Accelerated Solvent Extraction (ASE) which is an automated system that applies PLE technique. In ASE, the elevated pressure can go up to 1500 psi in order to keep the solvents in liquid state at temperatures above the boiling points (2011).

This study aims to investigate the effects of sample preparation, temperatures and static times on microalgae oil extraction by using ASE technique. ASE is an emerging extraction technique, and there are limited optimization studies of the microalgae oil extraction by using this technique. In this paper, preliminary results on the effects of ground samples, higher temperature and longer static time on extraction efficiency are presented.

MATERIALS AND METHODS

Microalgae cultivation

Chlorella protothecoides ATCC® 30581 (ATCC, United States) was used in this study. Microalgae was maintained in a growth chamber with light intensity varies from 38 - 47 μmol m^{-2} s^{-1} at 25 ℃ under a 14 hour light/10 hour dark cycle. Microalgae were subcultured into modified Medium 847 (Bristol's solution and yeast extract) as described in the Product Information Sheet for ATCC® 30581™. Wu's Basal Medium was used for inoculum preparation and microalgae cultivation. The components of Wu's Basal Medium were as follows: KH_2PO_4 0.7 g/L, K_2HPO_4 0.3 g/L, $MgSO_4.7H_2O$ 0.3 g/L, $FeSO_4.7H_2O$ 0.3 mg/L, glycine 0.1 g/L, vitamin B1 0.01 mg/L, A5 trace mineral solution 1 mL/L, 30 g/L glucose as the carbon substrate and 4 g/L yeast extract as the primary nitrogen source (O'Grady and Morgan, 2011, Xiong et al., 2008). Cultures were grown heterotrophically at 28 ℃ in 500 mL shake flasks containing 200 mL medium, with 10% (*v/v*) inoculum under continuous shaking (180 rpm). Algal biomass was harvested after 7 days by centrifugation at 7000 rpm for 5 min, washed with ultrapure water and lyophilized by freeze dryer (Gao et al., 2010, Miao and Wu, 2006). The ground samples were milled with bead beater (Mini-Beadbeater-24, Biospec Products, United States).

Oil extraction

Dionex ASE 350 (Thermo Fisher Scientific Inc., United States) was used for extracting oil from algal biomass. The samples for extraction were prepared by mixing dry algal biomass (0.25 g) with 6 g of Celite® Hyflo Supercel (Merck, Germany) before being loaded into 33 mL cells (Bodin et al., 2009). The detailed extraction process in Dionex ASE 350 is illustrated in Figure 1. In Experiment 1, the samples were extracted by ASE

with chloroform:methanol (2:1 (*v/v*)) (Mulbry et al., 2009). The extraction conditions were as follows: temperature, 120 ℃ ; static time, 5 min; rinse volume, 50% of cell volume; purge time, 60 s; with different static cycles namely two and 4 static cycle (Mulbry et al., 2009). The analytes were collected in pre-weighed collection bottles. The solvents were later evaporated under a stream of nitrogen. All tests were conducted in duplicate. Results are reported on dry weight basis (DW) whereby the oil yield is the percentage of oil to biomass.

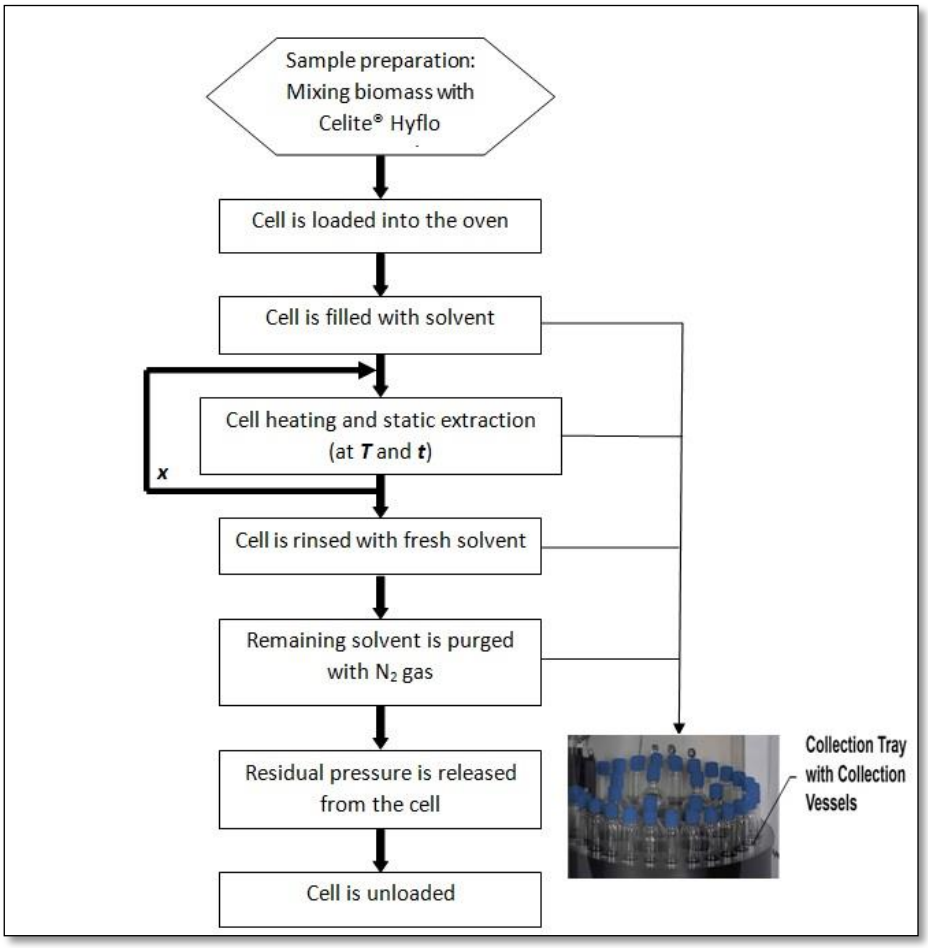

Figure 1. Dionex ASE 350 extraction process where T is operating temperature, t is static time and x is the number of static cycle (2011). The extracts were collected in pre-weighed collection bottles placed in collection tray.

Experiment 2 was carried out for extracting oil from dry algal biomass with 4 static cycles, and different parameters namely different sample preparations, temperatures and static times according to Table 1. This experiment was performed with the same solvents and analytes collection procedures used in Experiment 1. All tests were conducted in duplicate. Results are reported on dry weight basis (DW) whereby the oil yield is the percentage of oil to biomass.

Table 1. Different extraction conditions for Experiment 2 of oil extraction from *C. protothecoides* biomass by ASE.

Sample no.	Grinding	Temperature (℃)	Static time (min)
1	Ground	120	5
2	Not ground	150	5
3	Not ground	120	10

RESULTS AND DISCUSSION

Heterotrophic cultivation for oil production

In this study, algal biomass was obtained from harvesting *C. protothecoides* grown heterotrophically. *C. protothecoides* was chosen as previous studies showed that *Chlorella* sp. can be cultivated heterotrophically. It has been reported to yield high cell density and high lipids content under nitrogen-stress condition (Perez-Garcia et al., 2011).

The effects of the number of static cycles to algal oil extraction by ASE

Experiment 1 was conducted in order to determine the effects of the number of static cycles to the oil yield. From the results of Experiment 1 in Table 2, it showed that 4 static cycles gave 36.92% (*w/w*) more oil yield than 2 static cycles. Higher number of static cycles is beneficial as fresh solvent is loaded after every cycle, which helps keeping favourable extraction equilibrium of the process (2004).

Table 2. The effect of the number of static cycles to algal oil yield of *C. protothecoides* biomass by using ASE.

Number of static cycles	Oil yield (% (*w/w*))
2	19.04 ± 0.25
4	25.95 ± 0.98

The Effects of Samples Preparation, Temperature and Static Time to Algal Oil Extraction by ASE

In Experiment 2, dry algal biomass was extracted with different parameters in order to study the effects of sample preparation, temperature and static time to algal oil extraction by ASE. The number of static cycles used in these experiments was based on the results of Experiment 1 that showed 4 static cycles resulted on more oil yield. The results from Experiment 2 were presented in Table 3, which showed that ground samples, higher operating temperature and extended static time resulted on improved oil yield, compared to non-ground sample extracted at 120 ℃ for 5 min. Sample preparation proved to be crucial for extraction process by ASE as grinding the samples prior to extraction provides 62.20% (*w/w*) better extraction efficiency than non-ground sample. By grinding the samples, more surface area will be exposed compared to the non-ground one. Grinding by bead beating causes cell lysis through mechanical shearing from high speed spinning of fine beads (Lee et al., 2010). Operating temperature and static time are also among key parameters in ASE. By increasing temperature from 120 ℃ to 150 ℃, oil yield was increased by 40.66% (*w/w*). Elevated

temperature improves extraction efficiency as it causes a disruption of the analyte-sample matrix, improves solvent wetting on samples and enhances solvent penetration due to solvent viscosity reduction (Mustafa and Turner, 2011). Increasing static time from 5 min to 10 min enhanced oil yield by 39.73% (*w/w*). Longer static time at high temperature provides better diffusion of analytes retained within pores into the extraction solvent (2004).

Table 3. The effect of different extraction conditions to algal oil yield of *C. protothecoides* biomass by using ASE.

Sample no.	Oil yield (% (*w/w*))
1	42.09 ± 0.91
2	36.50 ± 0.37
3	36.00 ± 0.86

The results presented in Table 3 also showed that ground samples gave more dry weight of extracts, compared to oil extraction of non-ground samples with higher temperature (150℃) or longer static time (10 min). Even though grinding the samples resulted in the highest oil content extracted from algal biomass, further tests need to be conducted in determining optimum algal oil extraction as the temperatures and static times tested in this study were not at their optimal values. The extraction methods from Experiment 1 and Experiment 2 have high repeatability and high reproducibility, as the standard deviations of the oil yield were between 0.25 to 0.98% (*w/w*).

CONCLUSION

Preliminary results on algal oil extraction by ASE showed that grinding the samples, increasing temperature or increasing static time could enhance the oil yield. Samples preparation by grinding showed a larger effect to oil extraction compared to higher temperature and longer static time, as it resulted on the highest oil content from extraction of algal biomass. Although the results indicated that grinding may be more efficient in improvement of algal oil extraction than increasing temperature and static time, a comprehensive investigation is required to optimize the algal oil extraction conditions by ASE.

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ISLAMIC FINANCE IN AUSTRALIA: HISTORY AND DEVELOPMENT

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ABSTRACT

Over the past four decades or so, Islamic Finance has made impressive strides. As of 2012, it was reported that USD1.6 trillion of Islamic Finance assets were managed in *Shariah*-compliant accounts around the world. An additional substantial sum is represented by *Sukuk*, or Islamic bonds. Notably too, the development of Islamic Finance is not limited to Islamic countries, Global institutions such as HSBC, JP Morgan and others, have begun to offer *Shariah*-compliant financial services through their worldwide networks. The approach of the study is not supplemented by any empirical work. The method employed in this study is a mixture of direct observation from the legal and regulatory perspectives, literature reviews and the authors' personal experience and association with this industry. Through examining the above, this paper shall discuss the history, development and current issues of Islamic Finance in Australia.

Keywords: Islamic Finance, *Shariah*, Australia

INTRODUCTION

Islamic finance is defined as a financial service principally implemented to comply with the main tenets of *Shariah* or Islamic law. Over the past four decades or so, Islamic Finance has made impressive strides. The Islamic Financial Service Board estimates the Islamic Financial services industry's assets to be worth at USD1.6 trillion as of 31 December 2012 (IFN Alerts 2013). An additional substantial sum is represented by *Sukuk*, or Islamic bonds. Notably too, the development of Islamic Finance is not limited to Islamic countries, Global institutions such as HSBC, JP Morgan and others, have begun to offer *Shariah*-compliant financial services through their worldwide networks. Australia's Muslim population is increasing at a rapid pace, and based on the requirement of *Shariah*), one would expect an increase in demand for Islamic financial products. This paper will provide some brief introduction of Islamic finance plus explanation on the theoretical framework and key principles on which it was established. The current development and issues relating to Islamic finance in Australia will also be discussed.

ISLAMIC FINANCE IN THE MODERN ERA

Looking at history, Islamic finance in the modern era began some 40 years ago. Since then, it has achieved impressive results and made inroads into the conventional financial system. Though initially concentrated in the Middle East (especially Bahrain) and South-East Asia (particularly Malaysia), Islamic finance principles are now increasingly

found elsewhere. This includes developing economies where the financial sector is almost entirely Islamic (such as Iran and Sudan) or where Islamic and 'conventional' financial systems coexist (including Indonesia, Malaysia, Pakistan and the United Arab Emirates) (Gait & Worthington 2007). It also includes developed economies where a small number of Islamic financial institutions have been established and where large conventional banks have opened Islamic financing windows (such as in Europe and the United States) (Archer & Karim 2007).

Before the re-emergence of the Islamic financial system, Muslims throughout the world had only the conventional financial system to fulfil their financial needs. The Islamic resurgence in the late 1960s and 1970s initiated the call for a financial system that allowed Muslims to transact in a system that is in line with their religious beliefs. The Islamic Financial system involves a social implication which is necessarily connected with the Islamic order itself and represents a special characteristic that distinguishes Islamic financial institutions from other financial institutions based on other philosophies.

In exercising all its financial or developmental activities, the Islamic Financial Institutions ("IFIs") takes into prime consideration the social implications that may be brought by any decision or action taken by the IFIs. Profitability, despite its importance and priority, is not the sole criterion or the prime element in evaluating the performance of IFIs, since they have to match both the material and social objectives that would serve the interests of the community as a whole and help achieve their role in the sphere of social mutual guarantee (Saleem 2012). Social goals are understood to form an inseparable element of the Islamic financial system that cannot be dispensed with or neglected.

THEORETICAL FRAMEWORK OF ISLAMIC FINANCE

Figure 1 below illustrates the Islamic view of life of a Muslim and the place of his economic activities including banking and financial activities within the framework of such a view.

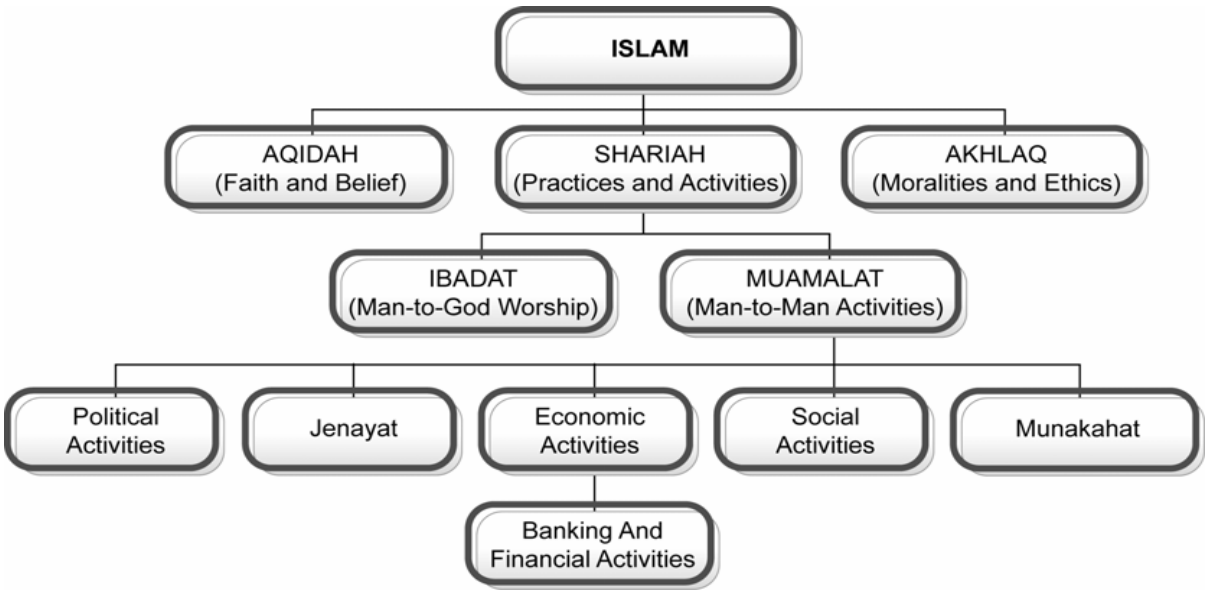

Figure 1. Theoretical Framework for Islamic finance and banking.

As shown above, Islam may be perceived as comprising three basic elements. The elements are:

a) *Aqidah* - This element is concerned with all forms of faith and belief of a Muslim in Allah (God) and His will, from the fundamental faith in His being to the ordinary belief in His individual commands.
b) *Shariah* - This element is concerned with all forms of practical actions by a Muslim manifesting his faith and belief. *Shariah*, being the practical aspect of a Muslim's daily life, is divided into two:
   (i) *Ibadat* - Concerned with the practicalities of a Muslim's worship of God, in the context of man-to-Allah relationship.
   (ii) *Muamalat* - Concerned with the practicalities of various forms of man-to-man relationships.
c) *Akhlaq* - This element is concerned with behaviour, attitude and work ethics with which a Muslim performs his practical actions.

A significant segment of *Muamalat* is the conduct of a Muslim's economic activities within the economic system. Within this economic system is the banking and financial system where he conducts his banking and financial activities. Thus, in the Islamic scheme of life and *Shariah* framework, a Muslim's banking and financial activities can be traced to his economic activities, to *Muamalat*, to *Shariah*, to Islam and finally, to God. This is the root of Islamic finance and banking.

SHARIAH COMPLIANCE

Shariah means path or way and represents the sacred laws of Islam. It is God's law according to all Muslim beliefs and cultures. *Shariah* rules and guides an individual's private and personal matters such as religion, hygiene, diet, dress code, and family life, as well as the general matters of community and society such as politics, crime, financial, and economic issues (Crawford et al. 2010; Thani et al. 2010). Within the Islamic scheme of life and S*hariah* framework, Islam imposes its *'ahkam'* (laws) or in modern terminology, sometimes referred to as norms or values, on its believers. These laws or values are not man-made, instead they are ordained by God. These laws are derived from the sources of *Shariah*. The main sources of *Shariah* are the *Al-Quran, Hadith, Sunna, Ijma, Qiyas* and *Ijtihad*.

The *Al- Quran* is the book of revelation given to the Prophet Muhammad (Peace and Blessing of Allah be upon him); *Hadith* is the narrative relating the deeds and utterances of Prophet Muhammad (pbAuh) ; *Sunna* refers to the habitual practice and behaviour of Prophet Muhammad (pbAuh) during his lifetime; *Ijma* is the consensus among religion scholars about specific issues not envisaged in either the *Holy Quran* or the *Sunna*; *Qiyas* is the use of deduction by analogy to provide an opinion on a case not referred to in the *Quran* or the *Sunna* in comparison with another case referred to in the *Quran* and the *Sunna*; and *Ijtihad* represents a jurists' independent reasoning relating to the applicability of certain *Shariah* rules on cases not mentioned in ether the *Quran* or the *Sunna* (Hussain 2011). These laws as derived from the primary sources are arranged into the following scheme of five levels (refer Figure 2).

a) *Fard* or *Wajib* (Compulsory)

Compulsory duties and acts to be performed by all Muslims. The omission of which is punishable.

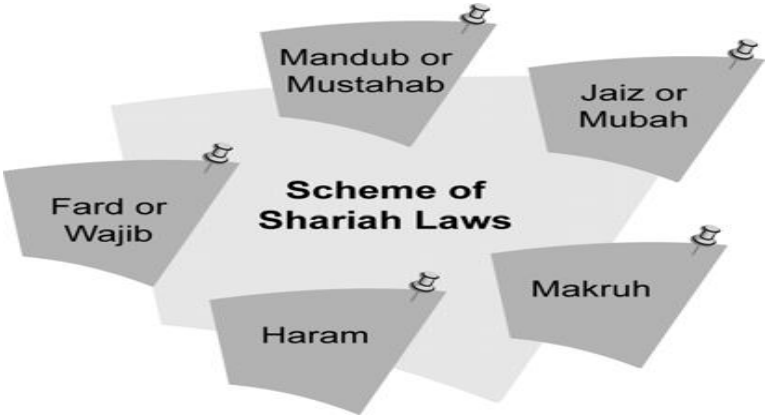

Figure 2. Scheme of shariah laws.

b) *Mandub* or *Mustahab* (Desirable)
An action which is rewarded but the omission is not punishable.

c) *Jaiz* or *Mubah* (Permissible)
An action if were performed or omitted is neither rewarded nor punishable.

d) *Makruh* (Disapproved)
An action which is disliked yet not punishable, but the omission is rewarded.

e) *Haram* (Forbidden)
An action under which is absolutely forbidden and punishable.

As a matter of fundamental principle, *shariah* law forbids any practices that are considered unfair and exploitative, and it promotes and encourages the welfare of the population (Crawford et al. 2010). *Shariah* provides sufficient tools of finance to meet all the lawful needs of man for commercial and investment transactions. These tools are based on the maxim of *al-Ghanam bil-gharm*. *Al-Ghanam*, in this context, means economic gain, profit and yield, whereas *Al-Gharm* refers to loss, risk and liability. The principle, therefore, connotes that no person is allowed to invest in a way that generates profit without exposing himself to the risk of loss rather it exposes both parties to the outcome of their deal whether it is a profit or a loss (Rosly 2005).

Islamic instruments of finance are indeed, just and fair in that they do not take-side with any of the contracting parties to the disadvantage of the other (El-Gamal 2002; Schoon 2008; Thani et al. 2010). Nevertheless, *Shariah* encourages all parties to take every precautionary measure to procure their due profit, avert and/or minimise loss. Such human effort can be done through collection of adequate and relevant data, appropriate analysis of information and use of a man's experience.

THE PRINCIPLES OF ISLAM IN CONTRACTS AND FINANCE

The Quran sets out principles of equity, justice, fairness, morality and social welfare, among others, as preferable underpinnings of any human society. It was explained in the Quran through surah *Al-Hadid* 57:30, *Al-Baqarah* 2:30, *Al-Ahzab*:72 and *Sad* 38:26,

that Allah (God) creates and owns everything and human beings therefore hold wealth on *amanah* (Trust) for God to be spent and dealt with accordingly. The beneficiary of such wealth, held by any human being, is the collective community of humans whose interest must be served in spending or dealing with money. Contractual dealings, whilst governed primarily by the principle of permissibility and recognising the freedom of the individual to contract freely (see Quran - surah *Al-Maidah* 5:1 and surah *An-Nisa* 4:29), was nonetheless to operate within the ambit of fairness as between the parties and social justice.

In general, it is accepted that in all matters (*muamalat*) other than faith (*ibadat*) the operating principle is that of permissibility (*ibaha*) unless there is a clear text in the primary sources to the contrary (Mansuri 2006b). The principle of permissibility does not operate in a vacuum but rather goes back, and is linked, to the notion of human beings as trustees or stewards of God's wealth/creation on earth. Permissibility is therefore tempered by rules enunciated in the Quran which indicate, broadly, the extent to which contracting parties are free in deciding their terms and conditions (Saleh 1992). Chief among these rules are that any given transaction should be devoid of *riba* or *gharar* (Mansuri 2006), both of which shall be discussed later in this paper.

In summary, fairness and the upholding of social justice in a contract, and permissibility are the main principles. These two principles provide a platform from which Islamic finance is to be applied in compliance with the objectives (*maqasid*) of the *Shariah*. Among the objectives of the sharia is the creation of ease (*maslaha*), both in this world and the hereafter (i.e. the material and spiritual spheres of existence), which is derived from the concept of *taysir* (making things easy) and relates closely to the concept of *raf ' al haraj* (the removal of hardship) (Bakar 2008; Hunt-Ahmed 2013).

SPECIFIC RULES OF THE *SHARIAH* GOVERNING CONTRACT AND FINANCE IN ISLAM

The specific rules of the *Shariah* governing contracts and finance whose parameters define the scope and nature of Islamic finance are explained briefly below:

Prohibition of Riba (usury or interest)

The basic tenets of Islamic Finance are clearly set out in the following two verses from the Quran:

"Those who eat Riba will not stand (on the day of Resurrection) except like the standing of a person beaten by Shaitan (satan) leading him to insanity. That is because they say: Trading is like Riba," whereas Allah has permitted trading and forbidden Riba. So whoever receives an admonition from his Lord and stops eating Riba, shall not be punished for the past; his case is for Allah (to judge); but whoever returns (to Riba), such are the dwellers of the fire – they will abide therein forever." Surah Al-Baqara 2:275 (Khan & Al-Hilali 2001).

"Allah will destroy Riba and give increase for Sadaqat (deeds of charity, alms). And Allah likes not the disbelievers, sinners." Surah Al-Baqara 2:276 (Khan & Al-Hilali 2001).

Islam prohibits *riba* as practised in conventional finance and banking operations. Prohibition of *riba*, a term literally meaning "an excess" and interpreted as "any unjustifiable increase of capital, whether in loans or sales," is the central tenet of the Islamic financial system. More precisely, any positive, fixed, predetermined rate tied to the maturity and the amount of principal (that is, guaranteed regardless of the performance of the investment) is considered *riba* and is prohibited (Iqbal & Mirakhor 2011). The general consensus among Islamic scholars is that *riba* covers not only usury but also the charging of "interest" as widely practiced (Iqbal & Mirakhor 2011). A direct implication of the prohibition of interest is that pure debt securities with predetermined interest rates are also prohibited. This prohibition is based on arguments of social justice, equality, and property rights. Islam encourages the earning of profits but forbids the charging of interest because profits, determined ex post, symbolize successful entrepreneurship and the creation of additional wealth. By contrast, interest, determined ex ante, is a cost that is accrued irrespective of the outcome of business operations and may not create wealth if there are business losses (Askari et al. 2010).

Balala (2010) argue that *riba* is not so much a matter of interest on loans (dayn) than it is a matter of distinguishing unlawful gain from legitimate gain especially because the Quran does not use *riba* in reference to loans but in reference to the unjustified (illegitimately or illicitly) taking of others' wealth, generally. The Quran's distinction between bay' and *riba* implies a distinction between a legitimate and non-legitimate transactions for purposes of drawing consideration or profit making. *Riba*, generally, pertains to the prohibition against eliciting illegitimate gains in any transaction, whether they are debt, sale, lease or a combination thereof in nature (Balala 2010). *Riba* is also seen to be an unfair practise that affects borrowers and lenders alike. Iqbal and Molyneux argue that the borrower must pay interest and repay the capital, as well as bearing any losses from the use of these funds (a form of 'double charging': that is, charging for both the funds and the use of the funds). In addition, *Riba* is also regarded as being unjust to the lender. This is because the real rate of interest may become negative if, say, the rate of inflation is higher than rate of interest. Therefore, lenders who wish to earn a profit from lending money could make a loss. Once again the loss incurred would be unrelated to the actual use of the funds (Iqbal & Molyneux 2005). In summary, *Shariah* are all out for serving the *Maslaha* or interest of man. It does not, therefore, prohibit things such as *riba*, merely for the sake of prohibition, but rather for the injurious effect it has on the *Maslaha*, be it personal and/or public.

Prohibition of *Gharar* (Uncertainty)

Gharar is often, and insufficiently, translated as uncertainty. It is much wider than uncertainty and encompasses speculation, excessive risk, ignorant and generally hints at consumer/investor protection (Balala 2010). *Gharar* can be any contract for sale or purchase that includes uncertainty in genus, species, quantity of the object, price, time of payment in deferred sales, existence of object, and identity of object. Although there is no explicit statement known in the *Quran* forbidding *Gharar*, it is well-accepted that it is forbidden. For example, the verse of the Quran from which the prohibition of *Gharar* is derived is surah *Al-Maidah* 5:90. It states: 'O you who believe! Intoxicants (all kind of alcoholic drinks) and gambling, *Al-Ansab* (animals that are sacrificed in the name of idols on their altars) and *Al-Azlam* (arrows for seeking luck or decision), are abominations of Satan's handiwork. So avoid (strictly all) that (abominations) in order that you may be successful' (Khan & Al-Hilali 2001).

There are many *Hadiths* (traditions) banning *Gharar* sales narrated by Muslims. For instance, "Ahmad and Ibn Majah narrated on the authority of Abu-said Al-khudriy: The Prophet Muhammad (pbAuh) forbade the sale of a runaway slave or animal, the sale of a bird in the air or fish in the sea, the sale of what the vendor is not able to deliver, or the unborn when the mother is not part of the transaction and milk in the udder (Yahya & Mubarakpuri 2002). This statement has been given considerable weight by *Shariah* scholars and is interpreted as having three juristic consequences: (i) a *gharar* sale is prohibited, (ii) such prohibition is total and extends to all transactions that qualify as a '*gharar* sale', and (iii) the effect of the prohibition is that a *gharar* sale is void (Balala 2010; Wan Ahmad 2008).

Iqbal and Molyneux (2005), suggest that "*Gharar* refers to acts and conditions in exchange contracts, the full implications of which are not clearly known to the parties.The existence of uncertainty in a contract is prohibited because it requires the occurrence of an event which may not ultimately occur. "Full disclosure" by both parties is the norm in contractual relationships. Any type of transaction where the (i) subject matter, (ii) the price, or both are not determined and fixed in advance amounts to "uncertainty". As a concept, it is predicated on the principles of equity and efficiency in transactions (Choudhury 2011).

Prohibition of *Maysir* (Gambling/Speculation)

Maysir is regarded by most Islamic scholars as gambling or any games of chance (including lotteries, lotto, casino-type games and betting on the outcomes of animal races). Together, these share a desire for obtaining return through deliberate risk-taking. The high risk available in these types of transactions, some people win a large amount of money, but others suffer from a loss of their money, and sometimes face bankruptcy (Iqbal & Molyneux 2005) . This could lead to greater financial and societal problems. In addition, these games and gambling are unnecessary for society because they cannot add any surplus to societal wealth.

Speculation is equivalent to gambling, and therefore is prohibited. This has essentially deterred many Islamic financial institutions from participating in derivative transactions. Speculative investments on the capital market in general are viewed suspiciously by *shariah* committees and avoided by financial institutions (Balala 2010). Caution must however be taken not to confuse risk with speculation. Risk taking is inevitable in commercial and investment transactions (the basis for making a profit/increased returns) (Askari et al. 2012). Speculation may on the other hand be viewed as excessive and/or avoidable risk taking.

Risk Sharing

Social justice demands that borrowers and lenders share rewards as well as losses in an equitable fashion and that the process of wealth accumulation and distribution in the economy be fair and representative of true productivity. Because interest is prohibited, pure debt security is eliminated from the system and therefore suppliers of funds become investors, rather than creditors. The provider of financial capital and the entrepreneur share business risks in return for shares of the profits and losses (Askari et al. 2012). Moreover, it is one of the objectives of *Shariah* that wealth should benefit not only its owner, but also the other contracting party and the society as a whole (Salem 2012).

Prohibited transactions or investments

Islamic financial institutions cannot provide finance for an activity which is prohibited by *Shariah* irrespective of its profitability and economic viability. These transactions are involving prohibited elements such as pork, alcohol, armaments, activity involving speculation, gambling and any sort of immorality. By extension, Islamic institutions may have reservations about (and refrain from) investments involving businesses such as hotels and the entertainment industry (where alcohol and pork may be served and gambling may take place) (Balala 2010; Tuma 2007). The aim of *Shariah* in this regard is to promote 'ethical' investments that again do not affect people and society adversely through the violation of religious prohibitions.

Financial assets

Money and financial assets in general are deemed merely media of exchange, not commodities that can be traded in (i.e. they are not deemed property). The sale of currency is therefore prohibited (both as a medium of exchange and/or a highly speculative investment) while the sale (through securitisation, restructuring or otherwise) of any debt remains largely doubtful in legality due to the scholastic consideration of debt as money (Balala 2010; Schoon 2008). Money is treated as "potential" capital – that is, it becomes actual capital only when it is joined with other resources in undertaking a productive activity. Islam recognized the time value of money but only when it acts as capital, not when it is "potential" capital (Askari et al. 2010).

Sanctity of contracts

Islam upholds contractual obligations and the disclosure of information as a sacred duty. This feature is intended to reduce the risk of asymmetric information and moral hazard (Askari et al. 2010).

Social justice

In principle, any transaction leading to injustice and exploitation is prohibited. A financial transaction should not lead to the exploitation of any party to the transaction. Exploitation entails the absence of information symmetry between parties to a contract (Askari et al. 2012). Based on the above backdrop, Islamic finance emphasises a close link between financial transaction and real economic activities. Islamic Finance, thus, is not only considered as a feasible and viable alternative for the conventional financial system but also a more efficient, productive and equitable way of financial intermediation (Khan 2010; Obaidullah & Latiff 2008).

INTRODUCTION TO ISLAMIC FINANCE METHODS

Islamic finance institutions (IFI) have developed a wide range of methods and/or techniques which allow them to uphold the religious and legal principles while enabling them, at the same time, to offer viable financial products. The search is actually still going on to find newer, and for variations based upon the existing ones to offer more attractive and useful instruments for the investors. The following list covers many of

them, but it is not considered as exhaustive (Ahmad et al. 2010; Hussain 2010; Karim 2010; Yahya et al. 2012):

- **Murabaha:** A form of asset financing where an IFI purchases an asset and then sells it to its client at a higher price (mark-up sale) with deferred payment terms. The interest that would ordinarily be paid by the client in a conventional loan – and which would constitute the bank's profit - is replaced by the difference between the purchase price and the sale price;
- **Mudaraba:** A form of limited partnership where an investor (the silent partner) gives money to an entrepreneur for investing in a commercial enterprise. The profits generated by the investment are shared between the partners in a predetermined ratio. The losses are borne only by the investor;
- **Musharaka:** Unlike a Mudaraba transaction, both partners in Musharaka must contribute capital to the partnership. Both partners and/ or one of them may manage the venture or alternatively both may appoint a third party manager to manage the investment. While profits may be shared in a pre-determined ratio, losses are shared in proportion to the capital contributed;
- **Ijara:** Similar to a hire-purchase, IFI purchases the asset and allows the customer to use it for an agreed period and for an agreed rent;
- **Sukuk:** Shariah-compliant financial certificates of investment that are similar to asset-backed bonds; and
- **Takaful:** Similar to a mutual insurance arrangement, a group of individuals pay money into a Takaful fund, which is then used to cover payouts to members of the group when a claim is made.

HISTORY AND DEVELOPMENT OF ISLAMIC FINANCE IN AUSTRALIA

In Australia, there are 20 locally owned Banks, 8 foreign subsidiary Banks and 40 branches of foreign Banks (APRA 2013). However, none of these Banks or any of the high street banks offered Islamic finance even though some of the foreign banks do provide Islamic finance facilities elsewhere. Australia's experience with Islamic financing has been relatively recent. The first attempt to introduce Islamic financing products in Australia was made by the Muslim Community Co-operative Australia (MCCA) (Ahmad et al. 2010). The organization began in 1989 with AU$22,300 worth of seeding capital and by 2003, MCCA had 5,600 members and deposits worth AU$24 million (Faruq & Rafique 2009). Majority of the MCCA members are from Melbourne and Sydney where the organization has a physical presence. Apart from MCCA, there is another two organisations that offers Islamic finance facilities: Islamic Co-operative Finance Australia Limited ('ICFAL') and Iskan Finance. In terms of Islamic fund management, there exists Crescent Investments and LM Investment Ltd (Farrar 2011). However, the expansion and growth of Islamic finance in Australia has been slow due to various reasons, for example lack of regulatory support and policy framework.

In July 2003 the *Weekend Australian* reported that the then Prime Minister John Howard had endorsed a shared partnership scheme between home buyers and banks which was very similar to schemes already being used by Islamic financial institutions (Faruq & Rafique 2009). In addition, a report published in *The Australian* on October 20, 2006 disclosed that National Australia Bank (NAB) will look at introducing Islamic financing into its product range to capture an "untapped" market that could be worth millions of dollars. It also declared offering a $25,000 post-graduate scholarship to a

member of the Muslim community for the year 2007 to further NAB's understanding of Islamic banking (Kerbaj 2006).

The Australian Government also committed to support the introduction of Islamic finance. In the opening speech by the then Assistant Treasurer of Australia while launching a book entitled "*Demystifying Islamic Finance – Correcting Misconceptions, Advancing Value Propositions"* in May 2010:

'We are taking a keen interest in ensuring there are no impediments to the development of Islamic finance in this country, to allow market forces to operate freely. This is in line with our commitment to foster an open and competitive financial system and a socially inclusive environment for all Australians. We also recognise that Islamic Finance has great potential for creating jobs and wealth' (Hussain 2010).

Recent developments in the field of Islamic finance have led to renewed interest in Australia as suggested by the sequence of events elaborated above.

Muslims in Australia

Muslim in Australia is a minority religious group. According to Census 2011, 476,300 people or 2.25% of the total Australian population were Muslims. This made Islam the fourth largest religious grouping, after all forms of Christianity (64%), no religion (22.9%) and Buddhism (2.5%) (ABS 2011). The Australian Muslim community is drawn from more than 70 different countries, is ethnically and linguistically diverse, and geographically scattered (DFAT 2008). There are indications that even earlier Muslim Arab explorations took place off northern Australia. The map of the Sea of Java of Muhammad ibn Musa al-Khwarizmi 820 CE shows, Cape York Peninsular, a "V" shaped Gulf of Carpentaria and a curved Arnhem Land. A later map by Abu Isak Al-Farisi Istakhari 934 CE, also includes an outline of the northern coast of Australia (Tames 1999).

The first regular Muslim contacts with Australia were made by the people of Makassar from Indonesia who had converted to Islam in the early 1600s. They traded with the Aboriginal people living along the northern coast from about 1650 until the early 1900s and influenced their language and culture. A few Muslim free settlers and some Muslim sailors arrived in the early years of settlement but little is known of them. The most significant early arrivals were the 'Afghan' cameleers who from 1860 to 1939 took part in expeditions to explore the interior. They were also involved in survey, construction and carrier work for the Overland Telegraph Line from 1870 to 1872, supplied the goldfields and provided an essential transport and communications network throughout Australia until they were superseded by rail, road and air services (Tames 1999).

Awareness of Islamic Finance in Australia

Empirical research on attitudes towards Islamic finance and banking has been limited globally. In Australia, only two known studies have been carried out to date (Farrar 2011) and only one on individual customers' attitudes, by Rammal and Zurbruegg. Their research was carried out in Adelaide in June 2004 and showed genuine interest amongst practising Muslims in the idea of Islamic banking products – but a lack of familiarity with Islamic brands and understanding of Islamic principles of financing

(Rammal & Zurbruegg 2007). The other study by Jalaluddin in 1999 surveyed the attitudes towards profit and loss finance methods of 385 small businesses and 80 financial Institutions in Sydney. He noted that 60 per cent of his small business respondents (the majority of whom were non-Muslim) expressed an interest in profit and loss (ie, *muđarabah*) financial arrangements and more than 40 per cent of the financial institutions were prepared to lend on that basis (Jalaluddin 1999) .

The latter study suggests policy makers should look beyond the actual numbers of the Muslim population when determining the potential market; Islamic finance is not just for Muslims. Evidence from Malaysia indicates a substantial take-up from non-Muslims attracted by the fair terms and quality of Islamic finance products (Venardos 2006). As such, it is imperative that additional steps to introduce Islamic finance in Australia to be taken so as to increase awareness and disseminate the correct information to the public.

Legal and Regulatory Framework

An appropriate legal and regulatory framework is a basic requirement for establishing and operating a sound financial institutions and markets. Similar to the Common law and Civil law systems the *Shariah* offers its own framework for the implementation of commercial and financial contracts and transactions (Ahmad 2008). However, not many countries have the appropriate financial, commercial and company laws to facilitate the implementation of Islamic finance and financial contracts. For example, in most countries, many Islamic banking and financial contracts are treated as buying and selling properties and hence are taxed twice. In some countries like the UK and Singapore, double stamp duty on some Islamic home finance schemes has been abolished so as to provide tax neutrality (Ahmad et al. 2010).

In Malaysia, the Stamp Act 1949 has been amended to cater for the Islamic finance in line with the government's policy to ensure tax neutrality between Islamic and conventional financing products (Thani et al. 2010). The additional instruments that are required to be executed in accordance with the Islamic principles have been given stamp duty exemption so that the stamp duty on the Islamic financing product is similar to that of the conventional product.

> Section 35 of the Stamp Act 1949 provides the following:
> The instruments appearing under the heading of "General Exemptions" in the First schedule shall not be chargeable with duty.
>
> "General Exemptions" in the First Schedule include:
> 6. An instrument executed pursuant to a scheme of financing approved by the Central Bank, the Labuan Offshore Financial Services Authority or the Securities Commission as a scheme which is in accordance with the principles of *Shariah*, where such instrument is an additional instrument strictly required for the purpose of compliance with those principles but which will not be required for any other scheme of financing.

Conventional financial laws also narrow the scope of activities of Islamic financial institutions within conventional limits. In the absence of Islamic finance and banking laws, the enforcement of agreements in courts may require extra efforts and costs. Therefore, banking and company laws in several countries require suitable

modifications to provide a level playing field for Islamic financial institutions (Ahmad 2004). Furthermore, international acceptance of Islamic financial contracts requires them to be *Shariah*-compatible as well as acceptable under the major legal regimes such as the Common law and Civil law systems.

Like many Western economies, Australia utilises a combination of market and government mechanisms to regulate the banking and finance industries. Government involvement operates to prevent market failure and also to facilitate efficient running of the markets. Australia uses three government regulatory agencies at the federal level:

1. Australian Prudential Regulation Authority ('APRA');
   APRA enforces prudential legislation and is in charged specifically with protecting the interests of depositors, insurance policy holders and superannuation fund members (APRA 2003). Islamic deposit-taking institutions, such as banks and cooperatives, and those running *Takaful* (Islamic insurance) operations, therefore, would have to deal with APRA. Under the *Banking Act 1959* (Government 2003), APRA can exert a significant degree of supervisory control through insertion of conditions requiring the holder of a licence to comply with any of its inquiries or directives.
2. Australian Securities and Investment Commission ('ASIC')
   ASIC supervise matters that fall outside the jurisdiction of APRA, for example supervision in the area of financial securities, financial instruments and stock exchanges. Like APRA, it has considerable scope to supervise Islamic financial institution through the conditions it imposes on its licensees and the need for self-reporting of breaches. ASIC's responsibilities fall under the *Corporations Act 2001* and are concerned more with market integrity in general and consumer protection. It has civil and criminal jurisdiction, has powers to investigate corporations, inspect books, call witnesses, require disclosure on the detail of financial products, and hold public hearings (Government 2001).
3. Reserve Bank of Australia ('RBA')
   The RBA, formally independent of the Federal Government, decides on monetary policy (similar as the Bank of England) and works to ensure stability of the financial system as a whole. Its responsibilities are covered by the *Reserve Bank Act 1959*. Since 1998, it has not been involved with prudential regulation of banks or other deposit-taking institutions. In addition to supervision from government regulators, Islamic finance service providers have to comply with directives from their market regulators, who are themselves subject to directives from ASIC and the overall supervision of the Minister (Farrar 2011).

As of this paper was written, there is no mechanism in Australia that would compel Islamic finance service providers to comply with regulations and directions of the international Islamic regulatory bodies, whether directly or indirectly. There are two international standards-setting bodies: the Islamic Financial Services Board ('IFSB') and the Accounting and Auditing Organisation for Islamic Financial Institutions ('AAOIFI'). The former is an association of central banks, monetary authorities and other institutions responsible for regulation and supervision of Islamic financial services. Its primary purpose is to set and harmonise standards for supervision and regulation internationally that are consistent with *Shariah* principles (Farrar 2011; Saleem 2012). IFSB also liaises and coordinates with standards-setting bodies from the conventional sector to promote stability and disseminate best practices. One of its most

important functions to date has been the adaptation of Basel II on capital adequacy requirements to Islamic finance service providers.

The AAOIFI is an autonomous international Islamic organisation which prepares accounting, auditing, governance, ethics and *Shariah* standards for Islamic finance service providers. Its members are drawn from certain Islamic financial institutions and *Fiqh* academies, including the Fiqh Academy of the Organisation of the Islamic Conference (OIC). The AAOIFI complements the IFSB through the setting and harmonising of *Shariah* standards. The rulings, standards and guidelines of both organisations are voluntary in nature but have been incorporated (directly and indirectly) into the domestic laws of some jurisdictions. In both Dubai and Bahrain, for example, the rulings of the AAOIFI are incorporated into local law (Krichene 2012). In Malaysia, on the other hand, they serve as benchmarks for general *Shariah* compliance, though ultimately decisions are left to the *Shariah* Advisory Councils of the Malaysian Central Bank and the Malaysian Securities Commission, respectively (Venardos 2011). The Malaysian Central Bank, as Malaysia's prudential authority, also takes into account the guidelines issued by the IFSB when issuing its own guidelines on appropriate governance and supervisory frameworks for Islamic finance service providers (though is not technically bound) (Thani et al. 2010; Venardos 2011).

Amending the current Australian legislation to require the Australian regulators to refer to the standards of AAOIFI, and the IFSB in particular, would fill an important gap in the Australian context and facilitate further development of Islamic finance in Australia (Thani et al. 2010).

Impediment issues related to Islamic Finance in Australia

According to Thani, Abdullah and Hassan, the Islamic Finance sector requires more than a receptive market; it also needs an enabling legal environment for both the retail and wholesale markets to prosper. In their analysis of the experiences of several countries, key factors in the successful development of Islamic finance have been: clear policy decisions and directions coordinated by local financial regulations; legislation establishing, licensing and supervising institutions offering Islamic finance services and clarifying the difference with conventional services; comprehensive and precise mechanisms that ensure systemic *Shariah* compliance, supervised by qualified Sharia scholars as part of a *Shariah* Advisory Board (SAB); taxation friendly frameworks which enable Islamic finance providers to compete effectively with providers of conventional finance; supporting infrastructures, including accounting standards and human resource development; and participation in global initiatives, such as the Islamic Financial Services Board (Thani et al. 2010).

Research conducted indicates that due to the unfamiliarity of the relatively new Islamic finance system, Islamic financial institutions in Australia have not been able to play the expected role in the development of Australian economy through mobilising funds and attracting more customers (Ahmad 2008). Other major obstacle in Australian regulatory system is its federal structure. All institutions, be they financial or otherwise, are required to follow both State and Federal regulations. These regulations may vary from State to State. The States and Territories may have different regulations. Thus lack of uniform regulations across all the six States and two Territories are also not conducive for growth of Islamic finance in Australia (Ahmad & Hassan 2006).

In September 2008, the Australian government commissioned a report into how to position Australia as a leading financial services hub in the Asia-Pacific region and as a result, the Johnson Report was introduced. The Johnson report made two specific recommendations on Islamic finance; the removal of regulatory barriers to the development of Islamic finance products in Australia, and a call for an inquiry by the Board of Taxation into whether Australian Tax law needs to be amended to ensure that Islamic financial products have parity of treatment with conventional banking products (Khan 2012). The focus of this report was not to give any special treatment to Islamic finance, but to make sure there is a level playing field for the development of Islamic finance in Australia. This wouldn't require large scale re-writing of the Australian law and merely targeting neutrality in treatment. For example, purchasing a home through an Islamic mortgage would result in double payment of stamp duty. This is because *Shariah*-compliance requires the asset to change hands twice. A neutral treatment would require amending the law such that the stamp duty is paid once or an equivalent amount in two instalments. The Victorian government already introduced such changes after working together with the Muslim Community Cooperative Australia Limited ('MCCA') (Khan 2012).

In April 2010, the Australian Government announced that the Board of Taxation would conduct a comprehensive analysis of Australia's tax laws as recommended by the Johnson Report and identified areas which might need fine-tuning. In further development, on 18 May 2010 the then Assistant Treasury Mr Nick Sherry announced the Terms of Reference for the Review (Government 2012). Among others the issue under review are as follows:

Review of the Tax Treatment of Islamic Finance

1. The Board of Taxation was asked to undertake a comprehensive review of Australia's tax laws to ensure that, wherever possible, they do not inhibit the expansion of Islamic finance, banking and insurance products.

2. The Board was asked to:
    i. identify impediments in current Australian tax laws (at the Commonwealth, State and Territory level) to the development and provision of Islamic financial products in Australia;
    ii. examine the tax policy response to the development of Islamic financial products in other jurisdictions (including the United Kingdom, France, South Korea and relevant Asian jurisdictions); and
    iii. make recommendations (for Commonwealth tax laws) and findings (for State and Territory tax laws) that will ensure, wherever possible, that Islamic financial products have parity of tax treatment with conventional products.

3. In conducting the review, the Board should have regard to the following principles as far as possible:

    i. The tax treatment of Islamic financial products should be based on their economic substance rather than their form.

ii. Where an Islamic financial product is economically equivalent to a conventional product, the tax treatment of the two products should be the same.

4. If the Board concludes that amendments to the tax law are required, the Board should consider whether adjustments can be made to existing tax frameworks rather than the development of specific provisions directed solely at Islamic financial products.

5. The Board was asked to report to the Assistant Treasurer by June 2011 (Sherry 2010).

In respond to the April 2010 announcement, the Chairman of the Board of Taxation, Mr Dick Warburton AO, announced the release of a discussion paper on the Board's review of the taxation treatment of Islamic finance, banking and insurance products in a statement dated 13 October 2010. To facilitate public consultation, the Board has developed a discussion paper as a basis for further discussion. The Board welcomes submissions on issues raised in the 84 pages discussion paper and sets the closing date for submissions on 17 December 2010. To assist in the Review process, the Board conducted consultation meetings on 8 November 2010 in Melbourne and 11 November 2010 in Sydney. The consultation meetings were attended by representatives from taxation professional bodies, major law and accounting firms, various major corporations and business associations. The Board was expected to provide a final report to the Assistant Treasurer by June 2011 after considering the views of all stakeholders (Government 2010).

The Board of Taxation has finally submitted its final report to the Government recently. The submission was informed to the general public by the Parliamentary Secretary to the Treasurer, The Hon Bernie Ripoll MP at the "Amanie Australia Islamic Finance Forum" in Melbourne on 16 April 2013 (Moore 2013). In his speech, Mr Ripoll said that Australia is making progress on implementing the recommendations of the 2010 Johnson Report. The Report made two specific recommendations relating to Islamic Finance (Ripoll 2013):

1. The first recommendation was to review Australia's tax laws to ensure that wherever possible they do not inhibit the provision of Islamic finance, banking and insurance products and that it has parity of tax treatment with conventional products - Mr Ripoll confirmed that the Board of Taxation has submitted the final report to the Government, which is considering the issues raised in the report.
2. The second recommendation was to review whether any regulatory barriers to the development of Islamic financial products in Australia – Mr Ripoll informed that currently there is no substantive regulatory barriers at the Commonwealth level.

However, to the best knowledge of the authors, the Australian Government has not release any decision with regards to the Board of Taxation's recommendations. Whatever decision of the Australian Government going to make, it will decide the future of Islamic finance in Australia. It is the much awaited decision by the local and foreign banks who has taken the wait and sees approach.

Other related Development

The Australian Islamic finance industry also recently welcomed the latest investment fund manager specializing in wholesale property that is *Shariah* compliant (Omran 2013). Piety Investments a Sydney based company, specialises in structuring and managing *Shariah* compliant investment funds across both residential development and commercial real estate within Australia. Piety offers property trusts aimed at offshore investors seeking to tap into the under-supply of Australian bricks and mortar. With the population continuing to grow rapidly from significant immigration and natural growth, the demand for quality commercial and residential housing continues to flourish. Piety Investments managed numerous large-scale residential and commercial developments for many years prior to attaining their wholesale Australia Financial Services License (PietyInvestment 2013). In another development, Crescent Wealth was given approval for its *Shariah* compliant "Crescent Wealth Superannuation Fund" (CWSF) in February 2013 (Omran 2013). Crescent Wealth is Australia's first dedicated Islamic wealth Manager offering superannuation that is based on Islamic investment principles. The trustee of the CWSF holds both an Australian Financial Services License (issued by ASIC) and a registrable Superannuation Entity License (issued by APRA) (CrescentWealth 2013). Both Piety Investment and Crescent Wealth brought an interesting development into the Australian Islamic finance industry. It is hope that such development will continue in the near future with the participation of more companies.

CONCLUSION

The combination of ethical, social and financial considerations makes Islamic finance an increasingly attractive proposition. Financial products that comply with *Shariah* principles offer a genuine alternative for both Australia's Muslim and non-Muslim population. It is natural that the Muslims in Australia like Muslims in any other countries wish to conduct their financial activities in accordance with the tenets of their Islamic belief. The Australian government has shown strong support towards the development of Islamic finance by making several initial steps to facilitate the establishment of a full fledge Islamic financial institutions that would cater for the needs of the people. The establishment of these institutions would enhance competition in the financial market by offering an alternative to the traditional interest based banking which ultimately would benefit the consumers including the Non-Muslims. Consequently, this would help the Australian economy by creating an opportunity to bring in foreign investments into Australia and also help expand its existing trade and economic ties with other Muslim countries.

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MANAGING CHANGE FOR ENVIRONMENTAL SUSTAINABILITY IN QUEENSLAND MANUFACTURING SMEs: AN OVERVIEW

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ABSTRACT

This is an overview of research proposal in studying small and medium sized enterprises (SMEs) that significantly contribute to the economic development of most countries and they are vitally important for a healthy dynamic market economy. An increase in awareness of environmental issues and improvements has influenced the demand for and development of environmentally friendly business practices. The main objective of the research is to explore the environmental change management process within Queensland manufacturing SME environmental sustainability (ES) champions. The study attempts to address a gap in the literature regarding ES change management in manufacturing SMEs and tries to fill a practical gap in the manufacturing SME sector by providing some ES strategies for SMEs. Outcomes are expected to contribute to research by improving practical understanding of how to optimise organisational change capabilities in relation to sustainability within the context of manufacturing SMEs. This research is designed to adopt an interpretive paradigm using qualitative methodology in order to examine the change management processes.

Keywords: SMEs, ES, environmental sustainability champions, change management.

INTRODUCTION

"A global agenda for change"
Our Common Future Chairman's Foreword (Brundtland 1987).

The Report of the World Commission on Environment and Development titled `Our Common Future' was officially launched at the General Assembly of the United Nations in 1987 (Chan, 2011; Lee, 2009; Roxas & Chadee, 2012). This was an urgent call made during the assembly which set a landmark for our future direction of global development that emphasise on environmental considerations. Also known as The Brundtland Report (Roxas & Chadee, 2012), it recognises the co-existence elements between the environment and development as where we all live and what we all do in attempting to improve our living condition within our environment. The term is recognised as "sustainable development" (Stoughton & Ludema, 2012 and Thomas et al., 2012) that defined for "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987, p. 24).

It was clear from the observation made by the Commission during their course of action that attitudes and organisational of society need major changes. In addition, it also stated that economic growth in this new era must be in tandem with policies that supports sustainability as well as environmental resource base expandability. Arising

from this urgent call, there has been an increasing awareness among national governments and multilateral institutions to acknowledge that development matters cannot exclude environmental issues. It is imperative to note that economic activity has multiplied to create a $13 trillion world economy and could grow further five to tenfold in the coming half century (Brundtland 1987). Considering the facts given, more and more resources will be utilised in order to fulfill growing human population needs and this could potentially damage our environment. As a result, the urgent calls made by the United Nations for changes must be answered immediately and it must involve all sort of humanity before it is too late. Therefore, this study investigates how ES champions in Queensland manufacturing SMEs manage change for ES in relation to the above problem.

ENVIRONMENTAL SUSTAINABILITY CHANGE MANAGEMENT IN MANUFACTURING SMEs

Overview

Small and Medium Sized Enterprises (SMEs) have been identified to assume a key role in economic development whereby their importance is a global phenomenon brought about by market forces, technological advances, personal career aspirations and underlying demographic changes of the population (Poole, 2009). Therefore, it is critical for SMEs to be competitive and resilient in order to achieve sustainable economic growth in order to contribute to a nation's economic development. However, there are many challenges faced by SMEs which could limit their achievements arising from factors such as globalisation, increasing customer expectations, technological advances, and increased competition (Banham, 2005).

Environmental issues awareness, environmental legislations and concern from many stakeholders have raised the demand for responsible business management practices to adopt a triple bottom line approach that includes the traditional economic function, but also ES and consideration of social impacts and public welfare (Ciasullo & Troisi, 2013; Elkington 1994; Jamali 2006; Lee 2009; Roxas & Chadee 2012). Gradual increase on public pressure and environmental regulations has prompted businesses to seek the many benefits associated with being “green”. Increasingly, organisations of all sizes are embracing the strategic importance of environmental management practices for business efficiency and cost savings along with competitive advantage (Bell, 2002). Although there is a significant amount of research on the technical side of ES initiatives in general (Wiesner et al., 2012), there is a dearth of research on change management and people side of these initiatives. Within a research context, most studies on the subject of ES change management have focused on the economic and financial aspects of ES of predominantly large firms (Epstein, 2008) while the ES change management experiences of SMEs remains largely unexplored (Wiesner et al., 2012). This is despite the fact that SMEs form a large and vital part of the Australian economy (Poole, 2009). For example, SMEs in Australia make up 97.3% of existing Australian businesses. SMEs also constitute at least eighty per cent of all global enterprises (OECD, 2002), and are responsible for at least 70% of the world’s production (O’Laoire & Welford, 1996), and approximately contribute up to 70% of global pollution (Seidel et al., 2008).

One of the major contributors to this pollution is the manufacturing sector. Manufacturing sector in Australia has undergone significant changes since the mid-1980s as a result of substantial tariff reductions and quantitative restrictions on imports

(Mahmood, 2004). In addition, the author states further that more trade barriers has been removed following the multilateral trade liberalisation endorsed by the World Trade Organization (WTO). As a result, foreign competition drives inefficient domestic producers to exploit scale economies, eliminate waste, adopt best practice technologies or forced to shut down (Mahmood, 2004). The environmental impact of manufacturing companies is significant owing to the employment of activities and processes to transform resources into finished products (Williamson et al., 2006). Moreover, the authors emphasised that manufacturing SMEs contributed to 60% of total carbon dioxide emissions, 60% of commercial waste and 80% of pollution incidents in the UK.

The business context of this study is conducted in Queensland, Australia (Figure 1 shows regions in the Queensland state). Queensland is located in the North-eastern seaboard of Australia covering 23% of Australian total land area or 1,730,648 sq. km (ABS 2010). The justification of undertaking this research is based upon the identification of a theoretical gap on environmental sustainability change management in Queensland manufacturing SMEs, and the lack of studies on this topic area in SMEs.

Figure1: Map of Queensland Regions (http://www.slq.qld.gov.au)

This research could also inform good practice and assist other manufacturing SMEs in their ES journeys. Further to this, it could act as an ES blue print that manufacturing SMEs could potentially utilise to not only enhance the successful implementation and management of ES change but also improve their competitive advantage and survival in the global market place, therefore contributing to the state of Queensland and Australia both from an economic and social aspect. In view of the discussion above, there is a particular need for manufacturing SMEs to embrace the triple bottom line approach for the good of the enterprise as well as all organisational stakeholders in an effort to achieve positive environmental sustainability outcomes.

Problem Statement

ES change is distinctive from other organisational changes because it usually involves economic, social and environmental change elements as an integral part of the overall change processes. However, there is a dearth of research about environmental sustainability change management practices in SMEs generally, but in manufacturing SMEs particularly (Chadee et al., 2011). Little is known about how manufacturing SMEs manage its organisational and human resource systems in an effort to achieve positive ES outcomes. Of the scarce amount of existing research on ES management in SMEs, most studies are descriptive focusing mainly on issues such as clean production measurement, awareness of environmental regulations, sources of advice and types of managerial response, or general attitudes to environmental action and regulations (Bansal & Bogner, 2002). Only a few studies of SMEs are from an ES change management perspective (Moore & Manring, 2009; Ronnenberg et al., 2011; Stone, 2006a, 2006b and Wiesner et al., 2011). There is also a particular need for manufacturing SMEs to embrace ES for the good of an enterprise as well as all organisational stakeholders (Epstein, 2008 and Hofmann et al., 2012). However, due to their lack of financial and human resources (Klewitz et al., 2012 and Roxas & Chadee, 2012), SMEs remain less informed of the importance and benefits of ES and its various approaches and tools (Chadee et al., 2011).

In addition, manufacturing SMEs accessibility to financial assistances such as bank loans is critical in order to funding their business activities. However, it was reported that lending to them has been on a decreasing side due to their difficulty in meeting tight lending standards imposed by financial intermediaries (Australian Government, 2011). This is because banks have acknowledged that borrowing firms' environmental impacts can have both financial and reputational consequences on banks. Therefore, they need to integrate Environmental Risk Management into their credit assessment as a counter measure (Xu, 2012). Taking this issue into consideration, it can be argued that ES practice is imperative for manufacturing SMEs' adoption due to their association with higher environmental risks in order to have better access to bank loans.

The question could be asked why manufacturing SMEs cannot rely on organisational change knowledge generated in, developed for and amongst large organisations. SMEs have some unique distinguishing characteristics (Klewitz et al., 2012 and Wiesner & Mcdonald, 2001). For example, strategic choices of the owner-manager and the choice of employing particular change management practices in an organisation are within the control of owner-manager. Furthermore, in contrast to large organisations, the SME owner-manager has much greater control (Roy et al., 2013 and Torugsa et al., 2012) over the development and utilisation of ES strategies. Resource and financial limitations also place a major restriction on SMEs' abilities to direct appropriate resources to ES initiatives and effective change efforts. Finally, smaller organisations are more likely to operate in an informal and flexible manner, which actually puts them in a better position to leverage their capacity for innovation, learning and change for sustainability (Hyvonen & Tuominen, 2006).

Justification of this Research

Despite the potential for ES change to contribute to innovation as well as transformational forces in generating new processes and products, the literature on this topic area within SMEs is still underdeveloped (Blum-Kusterer & Hussain, 2001; Bos-

Brouwers, 2010 and Wiesner et al., 2012). This study will firstly attempt to address this gap in the literature regarding ES change management. Within a research context, most studies on the subject of ES change management have focused on the economic and financial aspects of ES of predominantly large firms (Epstein, 2008) while the ES change management experiences of SMEs remains largely unexplored. In addition, this study will attempt to fill a practical gap in the manufacturing SME sector. Furthermore, there exists limited literature about ES change management practices in SMEs generally, but manufacturing SMEs particularly (Chadee et al., 2011). Little is known about how manufacturing SMEs manage their organisational and human resource systems in an effort to achieve positive ES outcomes. Wiesner et al. (2011) conducted one of the few studies on ES change management within an Australian context. The authors conducted a study to identify the key processes involved in ES change management processes in Queensland SMEs. Their study culminated in a framework on the main ES change management that are assumed to generally suit SMEs (Wiesner et al., 2011). However, their framework is yet to be tested specifically within the manufacturing industry, the latter being responsible for significant impacts on the environment through waste products, emissions and pollution.

Research on environmental change management remains scarce (Starik & Marcus, 2000). Of the little amount of existing research on SMEs, most studies are descriptive focusing mainly on issues such as clean production measurement, awareness of environmental regulations, sources of advice and types of managerial response, or general attitudes to environmental action and regulations (Bansal & Bogner, 2002). There are only a few studies of SMEs from an ES change management perspective. For example,Worthington and Patton (2005) examined the issue of sustainability intent, Moore and Manring (2009) explored sustainability strategy development, and Stone (2006a) and Stone (2006b) studied sustainability leadership, support communication and involvement. Despite the increased awareness surrounding ES issues and a growing pressure on manufacturing SMEs to adopt ES practices, there is little understanding of the management processes and practices necessary for these SMEs to successfully embark on an implement ES change initiatives. In addition to this, there is a dearth of studies focusing specifically on these issues within the manufacturing sector (Laforet & Tann 2006). A pilot study by Wiesner et al. (2012), has identified four main stages commonly involved in ES change management implementation within a cross section of Queensland SMEs. These stages are (i) design (ii) internalisation, (iii) implementation, and (iv) evaluation. However, the focus of this study is to investigate how the manufacturing sector of SMEs in Queensland pre-implement, internalise, implement and evaluate outcomes in relation to ES initiatives and thus attempt to fill the gap which currently exists within the manufacturing sector of SMEs.

METHODOLOGY AND RESEARCH DESIGN

The research design falls within the phenomenological paradigm that concerns with understanding human responses and behaviour from the participants own frame of reference (Hussey, 1997). This study also employs an interpretive paradigm using a qualitative methodology since the field of sustainability does not have a single, rigid methodology, and the use of interpretive methods are welcomed (Carroll, 1994). This approach facilitates a more in-depth understanding of the complex nature of change management since the sustainability change management field is still in an exploratory phase (Conger, 1998).

The research will be conducted using an emergent framework due to the lack of research on ES change management within the context of manufacturing SMEs. Case study methodology will be used in this research. Multiple-mini case studies will be carried out where each mini-case is considered as an independent experiment (Yin 2004) in generating the necessary information for the purposes of analysis. Interview data will be derived from semi-structured face-to-face interviews with a selected group of ES manufacturing SME champions in Queensland in order to generate a deeper understanding on how manufacturing SMEs manage ES change. The sampling frame in this study comprises a cross section of manufacturing SME ES champions in Queensland, Australia that have either won awards or have been publically recognised for their ES initiatives and achievements. Small enterprises are defined according to the Australian Bureau of Statistics classification as having 20 employees or less and medium businesses as having between 21-199 employees (Australian Government 2011).

Purposive sampling (Higginbottom 2004) is employed to select appropriate manufacturing SMEs for the study. The choice of an appropriate sample size will be guided by Baum (2003), that small sample size ranging between 12 and 20 is deemed acceptable when the aim is to study the topic of inquiry in depth and detail (Huberman & Miles 1994; Patton 2002). The CEOs of all the manufacturing SMEs on the list are contacted through formal letters to invite them and other relevant individual environmental champions to participate after explaining the purpose and scope of the study. Other firm-specific secondary company and sustainability documents as well as any publically available data on the sustainability efforts of manufacturing SMEs will also be collected for analysis purposes. All interviews will be voice recorded with the consent of interviewees and then will be transcribed. A thematic content analysis will be performed on interview data and secondary data using NVivo qualitative analysis software. Since the focus of this study is on Queensland SMEs, generalisations to the wider Australian context would be limited.

CONCLUSION

This study attempts to address a gap in the literature regarding ES change management in manufacturing SMEs. Secondly, this study also tries to fill a practical gap in the manufacturing SME sector by providing some ES strategies for SMEs. Outcomes are expected to contribute to research by improving practical understanding of how to optimise organisational change capabilities in relation to sustainability within the context of manufacturing SMEs. It may help SMEs meet growing expectations in relation to sustainability achievements. Furthermore, by providing guidelines to other manufacturing SMEs about integrating sustainability into their competitive strategy, and thereby obtaining greater profitability for SMEs through adoption of intentional environmental strategies, might help them to optimise their rate of change for sustainability. By focusing on manufacturing SME environmental sustainability champions, this study has the potential and ability to develop the internal strategic capabilities of manufacturing SMEs. A focus on experiences of manufacturing SME ES champions is new in the Australian context. Therefore, this research will assist by providing valuable learning experiences in relation to change management within an ES context for manufacturing SMEs.

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VISIBLE AND SHORTWAVE NEAR INFRARED SPECTROSCOPY TO PREDICT SUGARCANE QUALITY FROM CLEAR AND RAW JUICE SAMPLES

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ABSTRACT

The feasibility of using visible and shortwave near infrared (Vis/SWNIR) spectroscopy to predict soluble solids content (brix) and sucrose content (pol) from sugarcane juice samples was assessed. A total of 96 sugarcane juice samples for each clear and raw juice samples were used. The spectral measurements were collected by scanning the juice samples in a cuvette with 1 mm path length using transmittance mode. Principal component analysis (PCA) and partial least squares (PLS) analysis were used to interpret the spectra and develop both calibration and prediction models. The prediction performances for the clear juice samples were good with coefficient of determination (R^2) values of brix and pol were 0.85 and 0.87, respectively. For the raw juice samples, the prediction performances were acceptable with R^2 values for brix and pol were 0.72 and 0.75, respectively. The overall results indicated that the Vis/SWNIR spectroscopy combined with PLS models could be applied to predict sugarcane quality from both clear and raw sugarcane juices.

***Keywords*:** visible and shortwave near infrared spectroscopy; sugarcane; quality; raw juice; clear juice.

INTRODUCTION

Sugarcane (*Saccahrum* spp.) is an important crop in Australia with the production value ranging from AUD$1.5 to 2.5 billion per year (Anon., 2011). In the Australian sugarcane industry, growers are paid based on both yield and quality of their product. Sugarcane quality is determined based on its sugar content, known as commercial cane sugar (CCS). CCS is derived from brix (soluble solids content), pol (sucrose content) and fibre content. The brix and pol are usually measured in a laboratory using conventional measurement methods including refractometer, polarimeter and chromatographer. Lately, the applications of laboratory spectroscopic methods as rapid and simple measurement systems in measuring sugarcane quality parameters have been reported (Mehrotra and Siesler, 2003; Valderrama et al., 2007; Taira et al., 2010).

Recently, there is a growing interest within the industry to measure sugarcane quality in the field. Ability to measure sugarcane quality in the field will be very useful to the industry for assessing the crops growth and development, harvesting management

and adoption of the precision agriculture technique. Unfortunately, the conventional measurement methods and laboratory spectroscopic methods have great limitations for field uses because they are often time-consuming, operator dependent, and require hazardous reagents (Mehrotra and Siesler, 2003). Moreover, these laboratory technologies are not suitable to be used in the field considering the potential damage due to harsh and dusty environment in the field. This laboratory equipment is also expensive, thus should be handled with a great care.

Therefore, a portable, robust and low-cost spectrometer is more preferable for field use. Nowadays, a portable visible and shortwave near infrared (Vis/SWNIR) instrument with a wavelength range from 350 to 1100 nm appears promising for predicting fruit quality since the instrument is low-cost and portable enough for in-field measurements (Walsh et al., 2000). The applications of this equipment to measure sugarcane quality from stalk samples have been reported by Nawi et al., (2012, 2013a, 2013b). However, no study has reported the use of this equipment to measure sugarcane quality from juice samples. The application of this equipment seems to be feasible because it is small, portable and low-cost compare to other spectroscopy sensors. Therefore, the objectives of this study were (1) to investigate the feasibility of using Vis/SWNIR spectrometer to predict brix and pol in sugarcane juice samples; (2) to compare the prediction performance between clear and raw juice samples.

MATERIALS AND METHODS

Sugarcane Juice Samples

A total of 96 juice samples were collected for each clear and raw sugarcane juices. Each juice sample was extracted from a sample set consisted of a group of six whole stalk samples. Each sample set was collected from different field trials in Bundaberg, Australia throughout the harvest season in 2012. Each sample set was passed through a small mill at the Bureau of Sugar Experimental Station (BSES) laboratory complex in Bundaberg, Queensland, Australia. The first expressed juice was collected by hydraulically pressed the shredded cane samples. Then, the collected juices of each sample set were filtered and divided into two sets, one to determine brix and another one to determine pol. The brix (soluble solids content) measurement was done on raw juices using a Bellingham and Stanley RFM 310 refractometer. For pol measurement, the raw juice samples were first clarified using lead acetate to produce clear juices (Figure 1). Pol (sucrose content) measurement was done on clear juice samples using a Polartronic Universal automatic polarimeter (Schmidt + Haensch, Berlin, Germany).

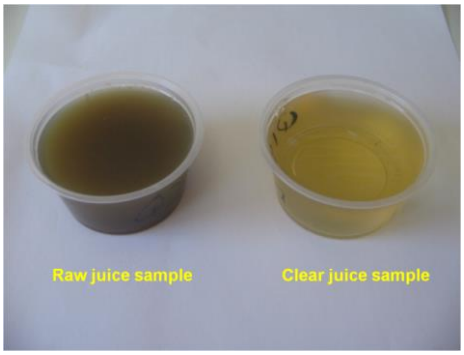

Figure 1. A comparison between raw and clear juice samples.

Instrument and Spectral Collection

The transmission spectra of the samples were measured using a handheld Vis/SWNIR Spectroradiometer (FieldSpec HandHeld and FieldSpec Pro FR, 325 to 1075 nm, Analytical Spectral Devices (ASD), Inc., Boulder, USA). The spectral measurements were conducted inside a black measurement box (900 x 600 x 450 mm). The box was built to enclose the sensor and the samples from the ambient light (Figure 2). The juice samples were placed into a plastic cuvette with 1 mm of optical path length. The field of view (FOV) of the spectroradiometer was 10°, giving a working distance of 45 mm from the cuvette with the diameter of the scanning area of 10 mm. A cuvette holder was built to firmly hold the cuvette inside the box throughout the experiments. One side of the cuvette was scanned using the sensor while on another side was illuminated with halogen lamp (Lowell Pro-Lam 14.5 V tungsten bulb, Ushio Lighting, Inc., Japan). The lamp was placed about 300 mm away from the measurement samples.

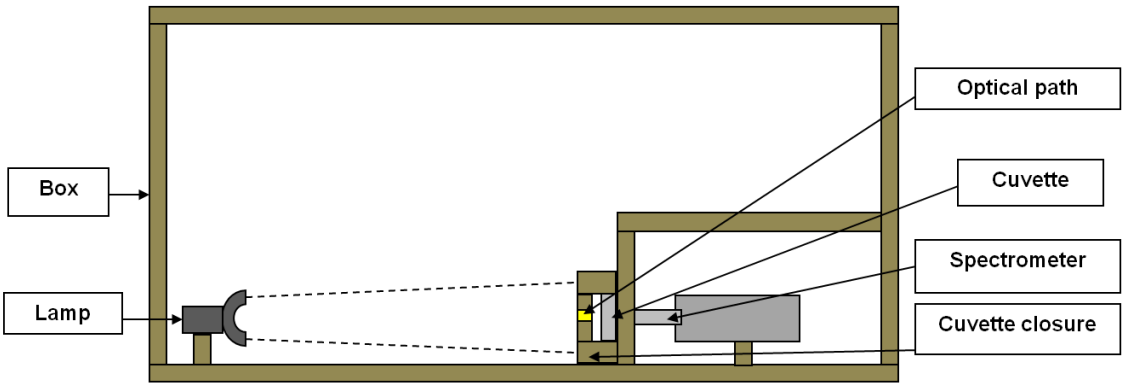

Figure 2. Simplified diagram of the transmittance measurement inside the measurement box.

The reference spectrum was acquired using the cuvette filled with distilled water and the dark spectrum was acquired when the lamps were off. Transmission spectra from 375 to 1075 nm were measured at 1.5 nm intervals with an average reading of 20 scans per spectrum. All spectral data were stored in a computer and processed using the RS3 software for Windows (Analytical Spectral Devices, Inc., Boulder, Colo.), designed with a graphical user interface. The transmission spectra were transformed into ASCII format by using the ASD ViewSpecPro software (Analytical Spectral Devices, Boulder, USA). Then, three spectra for each sample were averaged into one spectrum and transformed by log (1/T) into absorbance spectrum.

Multivariate Analysis

Before the calibration, the spectral data was pre-processed for optimal performance. Pre-processing of spectral data is a key part of spectral analysis to improve the accuracy. In this study, the effect of several pre-processing techniques on calibration model performance was investigated including smoothing technique of moving average, multiplicative scatter correction (MSC), first and second derivatives, standard normal variate (SNV) transformation and mean normalisation. After some trials and computations, MSC was found to be the best pre-processing technique for this study. In fact, MSC is the most popular normalisation technique offered by most chemometrics

software packages. MSC was used to correct the light scattering variations in the spectral data (Naes et al., 2004). The pre-processing processes were implemented using The Unscrambler, V 9.6 software (Camo Process AS, Oslo, Norway).

Prior to the development of calibration model, principal component analysis (PCA) was applied in analyzing the spectra data to extract useful information, decrease the noise and reduce the number of principle components (PCs). PCA is a well-known chemometrics method used to search for directions of maximum variability in sample grouping and uses them as new axes called principle components (PCs) that can be used as new variables, instead of the original data, in the following calculations (Blanco and Villarroya, 2002). PCA was also used to detect spectral outliers that might affect model performance in each data set (Moghimi et al., 2010). Two outliers were found in this study and they were removed prior to spectral analysis using partial least square (PLS) regression.

Partial least squares (PLS) analysis is commonly applied in the near infrared spectroscopy analysis. PLS analysis could be used to establish a regression model to perform the prediction of sugar content from sugarcane juices. PLS simultaneously considers the variable of matrix Y (brix and pol) and the variable of matrix X (spectral data). In this paper, PLS was applied as a regression method as well as a way to extract the latent variables (LVs). The LVs were considered as new eigenvectors of the original spectra to reduce the dimensionality and compress the original spectra data (Wu et al., 2008). The maximum numbers of LVs used in this study was set to ten. Due to a limited number of samples used, full cross validation (leave-one-out) was used to evaluate the prediction quality and prevent over fitting of the calibration model (Arana et al., 2005).

External validation method was also used in this study to check the performance of the PLS models. The external validation procedure determines the predictive ability of an equation, based on a sample set which has not been used in the calibration development. Before the calibration, samples were divided into two sets. One set (75% of samples) was used to develop a prediction equation (calibration set) and another set (25% of samples) was used to validate the predictive equation (validation set). Samples for validation were selected by taking one of every four samples from the entire sample set, taking care to ensure that each set included samples that covered the entire range of sugarcane quality values.

In this paper, both PCA for PLS modeling were run using the Unscrambler V 9.6. The performance of the final PLS models was evaluated by the coefficient of determination for calibration (R^2), root mean squares of calibration (RMSEC), and the coefficient of determination for prediction (R^2) and root mean squares of prediction (RMSEP). A proper model should have a low RMSEC, RMSEP and a high R^2 for both calibration and prediction models.

RESULTS AND DISCUSSION

Overview of the Spectra and Statistical Values of Brix and Pol

The typical absorbance spectra for each raw and clarified juice are shown in Figure 3. Both curves show a downward trend as the wavelength increased. A higher absorption level by raw juices was due to the presence of impurities, colour pigments and fine fibers (Cadet and Offmann, 1997). At 680 nm, spectra curve for raw juice displayed a weak peak while this peak was not observed for clear juice curve. The peak at 680 nm belongs to chlorophyll pigments (Abbott et al., 1997). For the clarified juice sample, the

chlorophyll content was eliminated through clarification process. For the raw juice sample, it can be seen that there was some noises in the range of 400-550 nm. Hence, to afford better comparison with better prediction performance, only the wavelength region from 600 to 1000 nm was used for the analysis in this study.

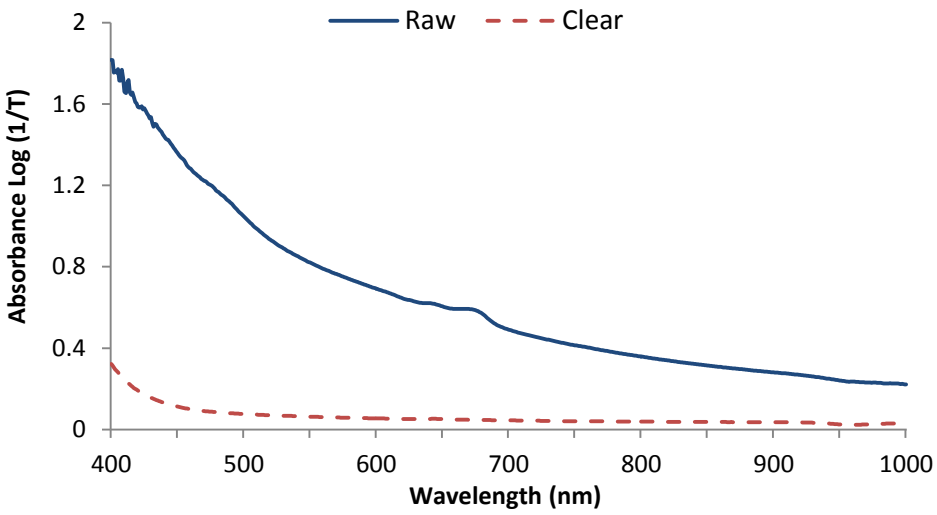

Figure 3. Typical absorbance spectra of raw and clear sugarcane juices.

The statistical characteristics of brix and pol for the juice samples for both calibration and prediction are shown in Table 1. Since, the samples in calibration and validation sets were selected systematically, it was found that the range and mean values of brix and pol were almost identical in both data sets. Since the data was collected from different locations throughout the whole harvest season, the brix and pol values in both data sets would be considered sufficient to represent the typical quality values of sugarcane during harvest.

Table 1. Statistical characteristic of the juice samples.

Parameters	Data set	Max	Min	Mean	Standard Deviation
Brix	Calibration	25.2	19.3	22.7	1.48
	Prediction	24.7	19.3	22.8	1.46
Pol	Calibration	100.6	71.0	88.3	8.07
	Prediction	98.8	71.7	88.8	7.31

PLS Models Performance

PLS models were developed and applied for calibration and prediction data sets. The performances of the models were evaluated by the prediction set using R^2 and RMSEP. The performances of the models in predicting the quality parameters are shown in Table 2. The prediction performance of the clear juice samples was good with R^2 values for brix and pol were 0.85 and 0.87, respectively. For the raw juice samples, the prediction performance was acceptable with R^2 values for brix and pol were 0.72 and 0.75, respectively. The prediction performance of clear juice was better than raw juice

because raw juice was an opaque, frothy and viscous liquid owing to the presence of colloidal substance. These substances would absorb energy from light source thus influence the prediction of sucrose content in the juices. In clear juice samples, those colloidal substances were removed through clarification process.

Table 2. PLS model performances for both juice samples.

Samples	Parameters	LVs	Calibration		Prediction	
			R^2	RMSEC	R^2	RMSEP
Clear juice	**Brix**	4	0.90	0.63	0.85	0.82
	Pol	10	0.91	3.28	0.87	4.10
Raw juice	**Brix**	6	0.92	0.55	0.72	1.08
	Pol	6	0.91	3.13	0.75	5.61

It can be seen from Table 2 that pol prediction for both juice samples are better than brix prediction. This finding is consistent with the study reported by Berding et al. (1991). The performance of prediction models of pol for both juice samples are presented by the scatter plots in Figure 4 (a) and (b), respectively. The performances of these models were evaluated by 22 juice samples in the prediction set. The R^2 for clear juice and raw juice were 0.87 and 0.75, respectively. Pol yielded better prediction performance than brix probably because pol was an estimation of sucrose content in juice whereas brix was just an estimation of soluble solids content in the juices. Roggo et al. (2004) claimed that spectroscopic method could be an accurate method to determine pol (sucrose content) and brix. The authors also reported that brix and sucrose are highly correlated, where sucrose content in brix was about 80%. This fact explained why pol prediction was better than brix prediction.

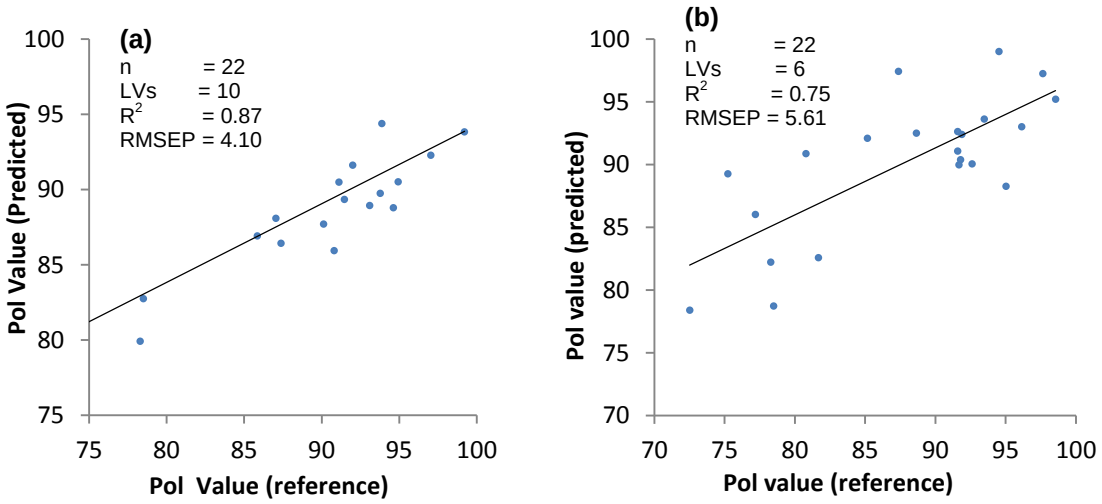

Figure 4. Scatter plots of reference versus predicted pol; (a) clear juice (b) raw juice.

CONCLUSION

The results obtained in this study demonstrated the potential of the Vis/SWNIR spectroscopy to predict brix and pol content in both clear and raw sugarcane juices. For the clear juice samples, the R^2 values for brix and pol prediction were 0.85 and 0.87,

respectively. While for the raw juice samples, the prediction accuracies of brix and pol were slightly lower than the clear juice samples with R^2 values of 0.72 and 0.75, respectively. The results of this study suggest that a low-cost and portable Vis/SWNIR spectrometer could offer the possibility to predict sugarcane quality in the field without the need for costly and laborious analysis using the conventional methods. However, the development of a portable mini sugarcane crusher would be needed to supply juice samples for the instrument in the field. Further studies are also needed in order to improve calibration specificity, accuracy and robustness, and to further interpret and develop new applications of this technique in the sugarcane industry.

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ENGLISH LANGUAGE IN THE MALAYSIAN EDUCATION SYSTEM: ITS EXISTENCE AND IMPLICATIONS

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ABSTRACT

This article sets out to give a historical account of English language education programs in Malaysia as a foundation for understanding the existence of English language in Malaysia and its importance to Malaysian learners. The language background of Malaysians is very much tied up with the historical and educational background of the country. English is taught as a compulsory subject in schools despite the evolution of the Malaysian education system toward *Bahasa Malaysia* as the language of instruction. Since 1974, communicative language teaching has been proposed for the English language syllabus and it is an approach to engage learners in interaction and meaningful communication. However, differences between the school and university classrooms differentiate the language learning process. Malaysian learners who still have to learn English in universities need to develop a positive attitude for meaningful learning to occur.

***Keywords*:** English language; Malaysian education system; communicative language teaching; language anxiety; bilingual system.

INTRODUCTION

English is an important second language (L2) and is widely spoken and used in the countries which were typically ex-colonies of the United Kingdom or the United States including Malaysia, India, Philippines and Nigeria (Thirusanku & Melor, 2012). For the past fifteen years, Malaysia is one of the Asian countries that has been adopting a bilingual system of education. In the case of Malaysia, the national language is *Bahasa Malaysia* and the government has agreed on English language as an additional language to be in the education system. The system aims at establishing a balance between national and international needs and challenges manifested through linguistic educational policies (Gill & Kirkpatrick, 2013). With reference to the Malaysian education system, English is placed as the L2 (Gill, 2002) in line with the education policy. English language is made a compulsory subject at all levels of education implying its existence "side by side with strong indigenous languages, wide use in speaking, and intranational outstanding, sometimes official functions, as the language of politics, the media, jurisdiction, higher education, and other such domains" (Thirusanku & Melor, 2012, p. 2). Reflecting on the Malaysian pluralist society, the learners are commonly bilingual, trilingual or even multilingual. Therefore, despite being competent

in the first language (L1), Malaysian learners should be aware of the necessity to master English language for future benefits.

In the Malaysian education system, English language learning takes place in classrooms; and Jeon-Ellis, Debski and Wiggleswort (2005) define the L2 classroom as "a social context to which learners bring themselves and their past experiences in which they establish certain relationships and attempt to participate and engage in tasks in ways that best fit their social needs" (p. 123). Excluding preschool level, the minimum formal learning of English language for Malaysian learners is eleven years and they continue learning English language in the tertiary level. Nevertheless, the deficiency in English competence among Malaysian learners is still the major concern among educators, in particular those in the tertiary institutions.

REFORMATION OF MALAYSIAN EDUCATION SYSTEM

Pre-independence

Initially, the Malays, being the local population, formed religious schools. The *Bahasa Melayu* was also the lingua franca for business communication purposes until the British came to Malaya (the name for Malaysia before independence). When the British administered Malaya from the eighteenth century till its independence (Fei, Siong, Kim, & Azizah, 2010), they not only established both English medium primary and secondary schools but the English language became the lingua franca for business communication purposes. The growth in Malaysian industry around rubber and tin attracted immigrants from China and India into Malaya. The immigrants also realised the importance of education and they established their own schools where the mother tongue (MT) of each ethnic group was the medium of instruction.

In general, prior to independence, the education system that existed in Malaya was a fragmented education system. The majority of the learners who attended the English medium primary schools were the Chinese since many lived in urban areas. A few Malays who benefitted from the English medium of instruction were the sons of royalty and chiefs; whereas the Indians remained in the estates and did not get the opportunity to attend the British education system due to economic disparity. Among the advantages promised to those learners who received education from the British education system were opportunities for further education, employment in the civil service, and access to scholarships. They were also highly regarded in the society and were offered important posts in the government then. Before independence, the educational system in Malaya was in accordance with the Barnes Report of 1951. The proposal was to develop a national school system in British Malaya by providing primary education for six years in both Malay and English languages. Other communities totally disagreed with the suggestion and felt that Chinese and Tamil should have been recognised too to represent the new definition of Malaya's national identity. At the end, the Barnes Report proved to be a failure. Consequently, the British approved bilingualism in Malay schools and trilingualism in the Chinese and Tamil schools.

With the objective to reform the Malayan education system, another educational proposal, the Razak Report, was released in 1956. The Education Committee was led by the late Minister for Education in the Federation of Malaysia Interim Government, Abdul Razak bin Hussain. An enhancement was made to the Barnes Report, which consequently endorsed the *Bahasa Melayu* as the medium of instruction while retaining

the vernacular schools of Chinese and Tamil. Since the goal was to unite all the races, the *Bahasa Melayu* was the principal language for national integration. The primary schools were Malay, English, Chinese and Tamil medium schools, whilst the secondary schools were Malay and English schools only. The National Education Policy was designed and included common content syllabus as to ensure that pupils would undergo the same process of enculturation. The report's terms of reference were to establish ''a national system of education acceptable to the people of the Federation as a whole which will satisfy their needs and promote their cultural, social, economic and political development, having regard to the intention to make Malay the national language of the country whilst preserving and sustaining the growth of the language and culture of other communities living in the country'' (Federation of Malaya, 1956, p. 1). In Malaysia an older generation (aged 50 and above) who had been English-educated prior to independence are now a minority. During their time, English was practically their first language or an important L2 where the British accent is still heard when they communicate in the English language.

Post-independence

Malaysia achieved its independence in 1957 and *Bahasa Malaysia* was proclaimed as the national language. Nevertheless, English was declared the second most important language in Malaysia after the national language. Consequently, English was used as the official language in administration. In 1960, the Minister of Education, Abdul Rahman bin Talib, set up a committee to review the implementation of the National Education Policy as suggested in the *Razak* Report. The Committee was named after its chairman, Abdul Rahman Talib, the Minister of Education then. The report, known as the *Rahman Talib* Report, was tabled with recommendations:

- To uphold the recommendations of the *Razak* Report;
- To have a bilingual (*Bahasa Malaysia* and English) medium of education in the schools. It was hoped that this would help unite the different races in Malaysia;
- To set up 'remove' classes for students from vernacular schools, where students spent one extra year learning English or *Bahasa Malaysia.* This was to help in the transition from primary education in the vernacular languages (Foo & Richards, 2004, p. 231).

The Education Act 1961 was produced based on both the *Razak* Report and the *Rahman Talib* Report. The Act contained a principal law that regulates education in Malaysia at all levels. It also introduced the national schools for Malay-medium primary schools and national-type schools referring to the vernacular schools. Other provisions were:

- *Bahasa Malaysia,* the national language, as the medium of instruction in schools;
- Providing a common curriculum
- Administering a common public examination for schools (Ales, 2010).

The National Education Policy was implemented in 1970. Gradually, the English medium schools were converted to national schools while retaining the national-type

schools. The Malaysian government enforced the phasing out of English language as the medium of instruction. The switch to *Bahasa Malaysia* as the medium of instruction was to be facilitated by learning the language as a subject in the national-type primary schools and a one-year language transition class – the Remove Class, attached to the Malay medium secondary schools. Nevertheless, English would become an important L2 taught in schools; thus, common content syllabi for English for both the primary and secondary schools were enacted. However, the switch between the languages saw a decline in the amount of English language exposure for Malaysian learners at schools.

In 1979 the Minister of Education then, Dr Mahathir Mohamad, tabled the outcomes after a committee reviewed the implementation of the National Education Policy. The major reformation to the education system was the launching of the New Primary Schools Curriculum or *Kurikulum Baru Sekolah Rendah* (KBSR) in 1983 and the Integrated Secondary Schools Curriculum or *Kurikulum Bersepadu Sekolah Menengah* (KBSM) in 1989. Both curricula were fully implemented by the year 2000. The aim of the KBSR is:

> "to equip learners with basic skills and knowledge of the English language so as to enable them to communicate both orally and in writing, in and out of school." ("Sukatan Pelajaran Kurikulum Bersepadu Sekolah Rendah Bahasa Inggeris," 200, p. 1)

Similarly, the aims of the KBSM are:

> "to extend learners' English language proficiency in order to meet their needs to use English in certain situations in everyday life, for knowledge acquisition, and for future workplace needs." ("Sukatan Pelajaran Kurikulum Bersepadu Sekolah Menengah Bahasa Inggeris ", 2000, p. 2)

The learning outcomes outlined in the KBSR encompass the four language skills – listening, speaking, reading and writing – reflecting the needs in the daily life of Malaysian society. The outcomes continue to the secondary school curriculum, KBSM, as an extension to give opportunities to learners to engage in wider reading for enjoyment and self-development, as well as to develop an understanding of other societies, cultures, values and traditions to contribute to emotional and spiritual growth. The KBSM English syllabus advocated the Communicative language teaching (CLT) syllabus integrating all four language skills to achieve a total development of all skills. To create enjoyment and for self-development, a literature component was introduced to the secondary school syllabus.

The change in the medium of instruction from English to *Bahasa Malaysia* has led to precipitous deterioration in the English language competence among Malaysian learners. One of the measures to arrest the decline in the English language competence was reintroducing of English as the medium of instruction for science and mathematics beginning Year 1 in primary school and Form 1 in secondary school by the Ministry of Education in 2003 (Stephen, 2013). The rationale of the move was to prepare learners at the tertiary level particularly on science and technology for most reference material is mainly in the English language. Furthermore, it was assumed necessary to prepare a technologically advanced workforce able to access the latest knowledge and research in English. However, the government aborted the policy in 2009 and announced the teaching of both subjects in the national language (Nor Hashimah, 2009).

In light of the economy, in the era of globalisation, Malaysia is requiring universal use of English for employment locally and in particular, for Malaysians to remain globally competitive. To reinforce the importance of both languages, under the Tenth Malaysia Plan for 2011 to 2015 (The Economic Planning Unit), the government has implemented the 'Upholding *Bahasa Melayu* and Strengthening English' program during the Plan period (p. 201). The objective of the program is to sustain *Bahasa Malaysia* as the official national language and retain the language as a medium of unity and solidarity, and simultaneously to enhance English proficiency among Malaysians to prepare them with a sense of competitiveness and capacity to explore new knowledge at national and international levels. The importance of English language is generally acknowledged and communicative language teaching (CLT) as an approach aims to prepare learners "to use the new language in speech and in writing for a variety of purposes and in a range of contexts" (Lewis, 2002, p. 40). Therefore, learning second and foreign languages requires the use of the target language (TL) meaningfully and authentically with the prescribed tasks for language learners to communicate meaningfully and actively to promote learning.

COMMUNICATIVE LANGUAGE TEACHING

Languages are different but learning English language and acquiring L1 are similar. Listening is another method to acquire L2. According to the acquisition-learning hypothesis of Krashen (1982), 'acquisition' is the product of a subconscious process very similar to the process when children acquire their L1. The acquired system requires meaningful interaction and natural communication in the L2 when interlocutors focus only on the communicative act. For L2 learners, they are much guided by the patterns from L1 that they have the tendency to use the patterns when interacting and communicating in L2 (Lado, 1957). In other words, Malaysian learners may be listening to English language to acquire the language; nevertheless, they use the patterns of L1 to communicate in the English language.

The Malaysian Curriculum Development Centre proposed CLT in 1974 for English language syllabus. CLT refers to both processes and goals in classroom learning with an attempt to operationalize the concept of communicative competence (Richards, 2002). CLT emphasises interactions as both the means and the ultimate goal of learning a language. The teaching and learning of English language in university adopts CLT, aiming to get learners engaged in real-life communication in the English language. The classroom enrolment in university, which is around 30 learners per group should enable English language teachers to assist individual learners to participate in the learning process for between 60-120 minutes in each lesson. This differs from classes in Malaysian schools, which are still large classes, normally around 40 learners. English language teachers are not able to ensure active participation in school classes within 40 to 80 minutes available in class sessions. CLT approach aims for meaningful communication through activities designed for learning. Since teaching and learning is a reciprocal process, learners play a major role to learn the TL. A piece of evidence from observation conducted by the first author on language learners suggests that there are three main attitudes of learners towards English language learning. First, learners react towards the English language as the first, second or even a foreign language. The reaction depends on, among other things, the locality the learners live in. Specifically, learners who resided and attended schools outside major cities or in rural areas tend to

place English language as a foreign language (EFL). This can be associated to the limited exposure and usage of English in contrast to learners who attend schools in urban areas. Second, learners in urban areas cover more domains of communication including the four skills as well as grammar, in contrast to learners in rural areas. Thus, the former group of learners feel comfortable communicating in the language outside English classes and with family members. In contrast, learners in rural areas find that learning English has no purpose and functions when they leave the class. They do not find the need to speak in the English language and they feel more comfortable speaking in their own MT. Both of these reasons concur with the claim made by Thornton and Houser (2005) that the engagement in the English language seems impossible when L2 learners get limited opportunity to use English outside the classroom with opportunities to speak and hear the TL happening only in the classroom. Third, a L2 speaker demonstrates a higher fluency than an EFL speaker of the same language. The reasons discussed indicate no surprise when EFL learners reveal negative attitudes such as being unenthusiastic and having low interest towards learning the TL. The situation can get worse with a discouraging environment to use the TL. The mixed background of L2 learners in tertiary classrooms is a challenge among themselves for them to overcome to be active learners of English language and also a challenge to the English teachers to cater to the individual needs.

The decision to revert to *Bahasa Malaysia* as the medium of instruction in the education system has created linguistic challenges among learners in Malaysian universities and "competence in English among learners has been on the decline since a change in language policy was enforced from that of English to *Bahasa Mal*aysia in 1970" (Chan & Wong, 2004, p. 1). The decline has led to a rise in the number of unemployed graduates who fail to secure jobs because of their lack of competence in the English language, evident particularly during interviews (Chan & Helen, 2006, p. 309). Nevertheless, the advent of Information Technology (IT) and globalization has made English language proficiency imperative for developing countries such as Malaysia.

In sum, Malaysian learners have long exposure to learning English language in schools. Similarly, CLT approach has been used in the English language curriculum in both primary and secondary levels. Besides the attitudes of the learners, studies also show the need of learners to overcome their affective factors, specifically language anxiety which they have accumulated throughout the eleven years to be able to participate in language learning in tertiary classrooms.

ENGLISH LANGUAGE LEARNING ANXIETY

In relation to language anxiety, Brown (1994) emphasises that learning L2 or FL is a complex task susceptible to human anxiety. The extent to which language learners participate actively in the language learning process is determined by their attitudes and anxiety level. Feeling positively towards the TL reveals the learner's positive attitude and consequently correlates to achievement in English language as well as successful acquisition in the TL. On the other hand, learners who have negative attitudes towards learning the TL do not expend the effort of speaking to acquire L2 aspects. Negative attitudes are associated with feelings such as uneasiness, frustration, self-doubt, and apprehension resulting in undue stress on the learners particularly when they are expected to participate actively within the language learning classroom. These negative feelings will demotivate them in learning the TL. According to Yang (2003) among

other affective variables, anxiety may be an important one since it not only inhibits learning and using English but it has detrimental effects on the learning process.

Language anxiety is defined as the feeling of tension and apprehension experienced by learners in the FL classroom (MacIntyre & Gardner, 1991). However, language anxiety is "a distinctive complex of self-perceptions, beliefs, feelings and behaviours related to classroom language learning process" (Horwitz, Horwitz, & Cope, 1986, p. 128). From the first author's perspective, this definition perfectly reflects the Malaysian English language learners because they are seen to have difficulty giving responses in the TL in language classrooms and they believe whatever responses they give must be correct responses. Other physical reactions from the learners include the feeling of discomfort in the English language class (Andrade & Williams, 2009). They may manifest nervousness, lack of confidence and physical changes. In a study conducted on a group of Malaysian tertiary learners, they claimed to experience nervousness and difficulty to speak in the English language and tended to be reticent and passive in classrooms (Noor Hashimah, 2007). In the same study, the group of learners were aware of their limited use of English language, which had been in the English language classroom only. Moreover, they felt some of their peers were more proficient than them. In relation to their English teachers, the learners worry if they would be negatively evaluated (Liu & Huang, 2011) and the instructors would point out their mistakes to the whole class, which can lead to personal embarrassment to individual learners. The factors of anxiety for Malaysian learners learning English language are personal, school instructional practices as well as social and cultural influences that made them linguistically and psychologically isolated from the English language use (Noor Hashimah, 2007; Rosemala, 2008).

The first author found that Malaysian English language learners in universities who achieved MUET between band 1 to 4 still experienced language anxiety. The situation worsened when they discovered that English courses are compulsory papers in university, in which they need to obtain a pass for every paper. Unless they change their preset minds towards English language learning, the learners will still experience anxiety "occurring at each stage of language learning namely acquisition (input), retention (processing) and production (output)" (Darmi & Albion, 2012, p. 171). This situation can further be supported with Krashen's (1982) affective filter hypothesis which explains how a combination of low level of affective variables raises the affective filter causing a mental block preventing information from being used for acquisition and results in poor language learning. The language anxiety experience by the Malaysian learners hinders them from being active learners as they consistently experience uneasiness in learning and thinking in the TL

CONCLUSION

Fundamentally, *Bahasa Malaysia* is accepted to unite the culturally multilingual society of the Malaysians; on the other hand, English language has a functional role because of its use as an international language of communication in the economy, thus, demonstrating its pervasive influence through its role in the education system. Language has to be communicated for learners to achieve competency; therefore, it is pertinent for Malaysian English language learners to overcome language anxiety so as to enable them to participate actively and meaningfully in language classes and be competent in the English language.

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DECODING THE FORBIDDEN 'PARANG' DESIGNS IN RAFFLES' BATIK COLLECTION

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This paper examines two important batik textiles held by the British Museum. The most famous of the carefully guarded Central Javanese forbidden Royal batik designs, *Parang* design, is found on these two batiks, collected by Sir Stamford Raffles who was Lieutenant Governor of Java for the duration of the brief British interregnum from1811 to 1816. During this time, Raffles sent home a number of batik pieces but was unfortunately destroyed when the ship that carried them burned at sea. A second shipment arrived safely; in 1939 two pieces were donated by his family to the museum of Mankind in London (Helen Ishwara et al 2012), which are now in British Museum and the focus of this paper. These two batiks are considered to be one of the earliest surviving items of Javanese batik and by exploring these two batiks in detail, I challenge the two hundred years old mystery of the origin of these two designs as well as how the carefully guarded forbidden batik designs of the Central Javanese royal courts came into the hands of Sir Stamford Raffles.

Batik is a textile using wax resist decoration technique which became a major form of artistic expression in Southeast Asia, particularly in the Indonesian archipelago where it was used as the preeminent vehicle for demarcating social status and for embedding religious beliefs in local Indonesian context. Unlike the woven textile, batik provides near limitless design scope within the confines of the fine lines that can be drawn directly with a *canting*, a tool made of bamboo handle and copper spout containing hot wax. Among the enormous variety of batik designs, those produced in Central Java are considered the epitome of classical batik, especially those created during the 18th century by Surakarta and Yogyakarta *kratons* (courts). These two principalities of the Islamic Kingdom of *Mataram* (1582 – 1755) are regarded as the twin capitals of classical batik and the great driving force behind the development of these designs. These classical designs have undergone changes in the course of time, but within the bounds of an evolving tradition. They are characterized by a narrow colour range dominated by deep blue or indigo and a somber brown, *soga*. With the original crème hue of the cloth, this led to the threesome of crème, indigo and brown: colours so distinctive of Central Javanese batik.

It was in the *kratons* of Surakarta and Yogyakarta that the eight renowned *Larangan* or forbidden motifs were designed and produced exclusively for court use, in particular after decrees announced in 1769, 1789 and 1790 (Fraser-Lu, 1986). These designs were believed to be talismanic of royalty: allowing others to use the designs might weaken royal power (Kerlogue, 2004). Each design contains a large variety of visual elements drawn from nature, religion, local myths, and other cultural sources. Some of these *Larangan* batik designs could link to Hindu and Buddhist belief; however, under Islamic court they too inherited the tradition of limiting

anthropomorphic representation which limits the portrayal of animal and human forms. The resulting abstract designs however are filled with visual metaphors. Their hidden meanings were obscure outside the royal 18th century courts; and remain so, today.

For many decades scholars have been trying to decode the original meanings of these visual metaphors but a consensus theory has yet to be established. According to Boow, "the meaning expressed in a batik pattern is rarely verbalised" and she realises that it is almost impossible to correctly assess and decode all the multiple levels of Central Javanese forbidden batik. Boow also quotes Jasper and Pirngadi who argue that the labelled names of specific batiks are symbolic, "the meaning of the patterns lies in the names" (Boow, 1998). Kerlogue however counters their argument, suggesting that the name may be discernible in the motif which may bear no relation to its ancient meaning. In short, to this day the pursuit of an accurate interpretation of the motifs of these forbidden designs remains complex.

The generally accepted eight *larangan* motifs in use on *kraton* batik were *Kawung, Parang, Parang rusak, Cemukiran, Sawat, Udan Liris, Semen,* and *Alasalasan* (McCabe Elliott, 2004). From a treaty between Raffles and Sultan Hamengkubuwono II in Yogyakarta we learn that by early 19th century the ban on the forbidden designs was lifted except for *Parang Rusak* and *Sawat*. The treaty in 1811 stated that "His Highness engages not to prohibit to any class of his subjects the use of any particular article or wearing-apparel, ornament or luxury, except the cloth called *parang roosa* and *sawat*, which from time immemorial have been appropriated to the Royal person" (Kerlogue, 2004). The reason behind the treaty is intriguing especially it was between Raffles and the Sultan, while the issue of prohibition was between the royalty and the commoners of Java. From the *History of Java* that was authored by Raffles in1817, he shows a keen interest in batik and has a chapter on batik. According to Raffles, "Among which there are patterns exclusively worn by sovereign, termed *batik parang rusa* and *batik sawat*, and others which designate the wearer, and are more or less esteemed, as well on this account as their comparative beauty of design and execution" (Raffles, 1817). The two batiks that Raffles brought back to England, curiously both feature the once forbidden *Parang* design.

This paper examines one of the most famous forbidden designs, *Parang* design that appears on Raffles' batik collection. *Parang* design is arranged diagonally or *garis miring* and more than 40 variants of *Parang* batik designs are known; all of them feature a series of broad light-coloured bands bound by undulating or scalloped edges. A *Parang* is one of the most ancient weapons in the Malay world, a long-bladed hard edged knife with handle (Fig.1). *Parang* batik designs have become associated with knives, fighting and war. If this assumption is correct, then a design that generates power was naturally reserved for the sultan's family. But seeing a *Parang* knife in the batik of *Parang* design is not necessarily obvious at all. Although the sketches of the *Parang* before the dying process may appear knife-like, this is lost however, following multiple dyeing processes (Fig. 2 & 3).

Figure 1. *Parang Knife*

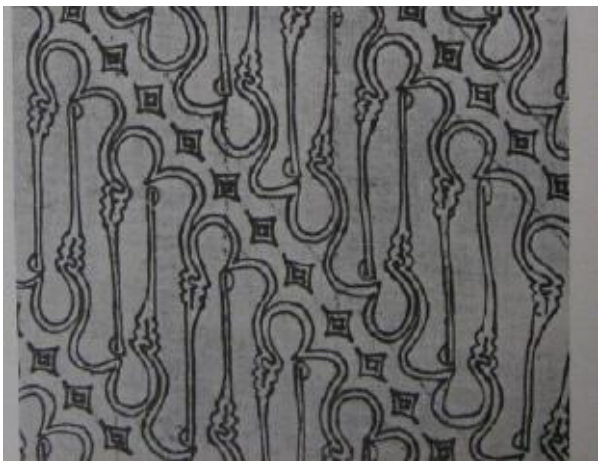

Figure 2. *Parang* design- sketches.

Figure 3. *Parang* design – batik.

One other variant design of *Parang* is *Parang Rusak that* is well worth examining here as it also formed one of the forbidden designs. *Parang Rusak* is another diagonally arranged design and is a softer version of the *Parang* design (Fig.4). It appeared to be popular in the Javanese court and was one of the last two forbidden designs after the treaty was signed in 1811. *Rusak* in Malay means 'damaged' or 'broken' and *Parang rusak*, literally means 'broken dagger'. The main difference between *Parang* and *Parang Rusak* is that *Parang* has straight lines running down from the scallop shaped head, whereas *Parang Rusak* has wavy, undulating lines from the scalloped head down. What is 'broken' is not clear. It is difficult to grasp why the royalty would consider a 'broken dagger' an important symbol. One legend holds that Prince *Panji* of Java was once saved by the protective powers of *Parang Rusak* (Kerlogue, 2004). Some scholars have suggested that a broken dagger signifies 'enemy destroying' (McCabe Elliot, 1984) but there is no evidence for this. Leo Chu proposes, perhaps fancifully, that both diagonally arranged forbidden designs are so arranged for camouflage. He states, "The use of the *parang rusak* pattern might be seen to relate to the environmental conditions of Indonesia which has a tropical rainforest climate experiencing convectional rain everyday and producing diagonal lines everywhere…During a rainy day, the patterns help to camouflage the wearer into the diagonal lines produced by the rain, which

confirm the notion that they come from the supernatural world" (Chu, 2010). He proposes no evidence for camouflage being used during the 18th century however.

Apart from the internet sources which often provide alternative explanation, my informant, Mr Najib Nugroho, Guide of Danar Hadi museum in Surakarta, also offers an alternative interpretation. According to Najib, the word '*Parang*'used in this context is not from the Malay term '*parang*' which means dagger; but it is in fact from the Javanese word '*pereng*' meaning 'slope', specifically referring to the 'slope of coral reefs by the shore'. In the Javanese English dictionary [http://kamusjawa.info/], '*pereng*' is translated as 'slope' and 'steeply sloping riverbank or mountain side' which appears to match Mr Najib's explanation. Also, in Robson and Wibisono's *Javanese English Dictionary* (Periplus, 2002) two meanings for '*parang'* are given: 'cliff' and 'knife'. It appears '*Parang'* is a variant of '*Pereng'* in Javanese, both bearing the same meaning i.e. slope.

Najib also suggests '*Parang rusak'* was created by the first king of *Mataram*, Panembahan Senopati, when he was meditating on the southern coast of Java. Whilst watching the waves break over the standing coral, he was amazed at the slope of the coral reefs which were crushed by the waves of the ocean. It is from here that the Javanese term '*rusak'* meaning 'broken' may be derived. This is articulated by the more wavy design of the *Parang rusak* which, unlike the *Parang* design, consists of rows of steep slopes. This Javanese interpretation may prove to be a more robust explanation than long held scholarly interpretations that decode a knife in Malay (Indonesian) language. And there are indeed several coastal areas which have long stretches of coral reefs along the shorelines of the South Java Sea named *Parang Kusuma*, *Parang Tritis* and a district of *Parang Gupito* in southern *Wonogiri*. It definitely seems to me more appropriate to associate these diagonally arranged designs with the slope of coral than with knives.

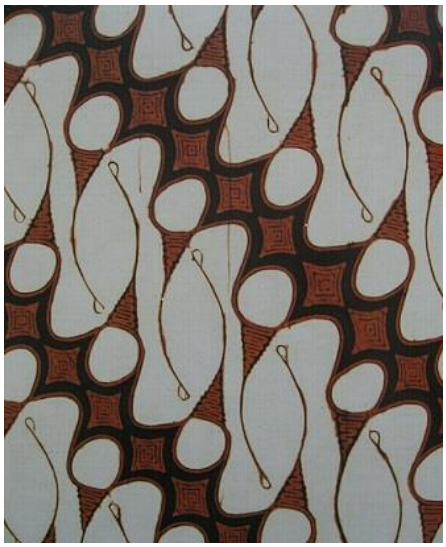

Figure 4. *Parang Rusak* design –batik.

As said, the batiks brought back from Java to England by Raffles are of the forbidden *Parang* designs (Fig. 5). In 1816 one of Raffles' aides recorded in his journal that he had received from a Yogyakarta Prince the gift of a batik cloth "such as is worn by the royal family" (Kerlogue, 2004). Kerlogue therefore surmises it is 'likely' that they were a gift from the court. As the ban was lifted in early 19th century, it is therefore possible that a Yogyakarta Prince would present, *Batik Parang* to Raffles. However, it is intriguing to think why an early 19th century Yogyakarta Prince would present batiks which were once an instrument of

power, to a British Governor who had not only captured Java but also reduced the Sultan to a kind of civil servant in the British colonial system? By analysing the language used in the journal entry, it could be interpreted that the batiks were *similar* to those worn at court rather than actual royal court batik. The batiks designs could look akin to what the royal family was wearing, especially to the uninitiated eyes. Furthermore, the layout of what survives of Raffles' two pieces of batik in the British Museum is highly unusual, they bear the courtly *Parang* design, combined with the *kepala* section of *Tumpal* design (Triangles pointing each other, a design most likely rooted in India). These textiles could be easily linked to the *Pasisir* district of Java rather than the courtly *Kratons* of Central Java. As the use of '*Kepala Tumpal*' design is not common at all for courtly batik designs of that era.

It is important to note that, on the Javanese north coast (known as Pasisir), at some distance from the Central Javanese sultanate courts, batik designs have less ancient symbolic value than those of Central Java. While Central Java adhered strictly to traditions, the more dynamic *Pasisir* seaports that attracted international merchants constantly developed new designs, introduced vivid colours of chemical dyes and incorporated foreign elements including Indian, Chinese and European. There in *Pasisir*, batik sarongs (cloth with both ends sewn together to form a tube) are separated into sections called '*kepala*','*papan*' and '*badan*'. '*Kepala'* or 'head' forms about one third of the cloth and is worn in the front. '*Papan'* is the 'border' at each side of the '*kepala'*. '*Badan'* or 'body' makes up the rest of the cloth which is draped at the back. Some writers including Van Roojen, Ishwara, Yahya and Moeis observe that the development of *kepala* designs is an interesting innovation exclusive to Javanese north coast producers (Van Roojen, 1994; Helen Ishwara et al, 2012).

Figure 5. Two Batiks featuring *Parang* Design (19th cent.)
Left: 218cm X 118cm. Right: 234cm x 85cm, The Trustees of British Museum

We know that these two batiks could either came in through the second shipment that Raffles sent home or personally brought back by him. Thus they are unlikely to be his earlier

collections and we cannot even be certain they were the pieces that referred to by Raffles' aide. Alternatively, Raffles may have had copies made of the forbidden *Parang* designs, perhaps somewhere on the north coast of Java. This could be one of the possibilities especially when the ban on forbidden design was lifted and copies were made legalised. Curiously enough, was the treaty between Raffles and the Sultan of Yogyakarta in 1811 meant to facilitate these designs to be copied freely not only by the commoners but also by Sir Stamford Raffles himself? The mystery of how these two batiks came into Raffles' collection, as well as the meaning of *Parang* design in these two batiks needs further exploration.

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THE ROLE OF SOCIAL MEDIA IN BUSINESS-TO-BUSINESS RELATIONSHIP MARKETING

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ABSTRACT

The evolution of World Wide Web has made social media becoming the most important medium for business-to-business (B2B) commerce. Despite the increasing trends of social media utilisations among B2B companies, studies into social media are very limited and emphasise more on the consumer of business-to-consumer (B2C) rather than on B2B typed of businesses. The degree to which social media is utilised by businesses, especially based on the types of B2B marketing relationships, is also not well understood in a comprehensive way. The main objective of this study is to assess the utilisation of social media in the perspective of B2B relationship marketing. This paper outlines four research questions through the review of related literatures. The study plans to utilise a qualitative approach, specifically an in-depth semi-structured interviewing technique to a range of 20 to 25 participants who work in the business relation related fields.

Keywords: Social Media, Business-to-business (B2B), Relationship Marketing, Web 2.0, and Relational Exchange.

INTRODUCTION

There were many research developments associated with different marketing emphases throughout the twentieth century (Egan, 2011). However, in the mid-1990s were when Sheth and Parvatiyar (1995) observed that the orientation of marketing field was undergoing a transition; from transactional marketing to relationship marketing. The concept of relationship marketing was no longer limited to the idea of marketing exchange, but the concept put more emphasis on emotional bonding. Sheth and Parvatiyar (1995) observed that businesses which understood and appreciated each other's constraints and needs were more likely to have good relationships with one another. The shift of marketing paradigm was discovered by the importance of relational bonding between traders, way before its revolution in 1950s (Egan, 2011). The 1950s were the era of consumer marketing (Christopher et al., 1991) and the age which represented a turning point for marketing thoughts (Egan, 2011). During this pre-industrial age, the marketing paradigm was mostly associated with the concepts of brand marketing and corporate manufacturers. Often, sellers of this era had direct

relationships with their buyers and developed permanent relationships to sell goods on daily basis in the marketplace (Sheth and Parvatiyar, 1995).

From the 1990s onwards, relationship marketing has become one of the most repeated phrases in business publications and in scholarly marketing journals (Egan, 2011). Practice and research in marketing journals during the previous twenty years aims specifically to the importance of interactions, networks, and relationships (Aaltonen, 2004). However, the literature mainly focuses in dealing with a particular issue of relationship marketing such as call centres, rewards clubs, and databases for direct marketing (Gummesson, 1998). As a concept, relationship marketing has expanded in the recently changing environment (Ha, 1998). Nowadays, relationship marketing focuses more on a multiple issues such as building, maintaining and retaining customers, rather than focuses on a single issue. According to Aaltonen (2004), organisation's profitability tends to rise as the retention rate increases, and the retention rate tend to rise as consumer satisfaction increases. Based on a study of more than 100 organisations in 24 industries, Reichheld and Sasser (1990) demonstrated that there is a high correlation between an organisation's profitability and its buyer retention rate. With an only 5% decreases in buyer defection rate, a seller can increase its profit by 25% to 85% (Reichheld and Sasser, 1990). In another analysis, a decrease of seller defection rate by 10% (from 20% to 10%) may result the seller with double (from 5 years to 10 years) the average length of its relationship with buyers (Payne and Frow, 2000). The pattern is the same across broad range of industries where the longer a seller retains its buyers, the higher level of profitability the seller tends to achieve (Reichheld and Sasser, 1990).

DIVERGENCE OF RELATIONSHIP MARKETING PERSPECTIVES

There is a limited consensus in the way how relationship marketing concept should be described. An analysis of scholarly literature reveals that relationship marketing, directly or indirectly, has been conceptualised in various perspectives including in the perspective of (1) philosophy (Fairhust 2001; Hasan 2003; Piccoli, O'Connor, Capaccioli, Alvarez, 2003), (2) strategy (Adenbajo 2003; Croteau and Li 2003; Kracklauer, Passenheim, and Seifert 2001; Tan, Yen and Fang 2002, Verhoef and Donkers 2001), and (3) technological tool (Gefen and Ridings 2002; Shoemaker, 2001).

Relationship Marketing as a Philosophy

> [Relationship marketing] is not a discrete project - it is a business philosophy aimed at achieving customer centricity for the company (Hasan 2003, p.16).

From the philosophical perspective, relationship marketing is often being referred as the idea that loyalty can be achieved by developing, maintaining, and improving long-term relationships with buyers. Instead of treating recurring interactions between sellers and buyers as a separate occasion, the philosophical standpoint of relationship marketing emphasises that buyer loyalty toward sellers will only be attained if the interactions are seen as an ongoing relationship (Piccoli et al., 2003). As business philosophy, relationship marketing is also closely related to the marketing exchange concept (Hasan, 2003) which emphasises that sellers should work around their buyers' changing needs (Kohli and Jaworski, 1990). This viewpoint recognizes that in order for sellers to develop profitable and long-term relationships, sellers' strategy should be

driven by a strong comprehension of buyers' changing needs (Rigby et al., 2002; Wilson, Daniel, and McDonald, 2002).

Relationship Marketing as a Strategy

> [Relationship marketing enables sellers to] invest in the customers that are (potentially) valuable for the company, but also minimize their investments in non-valuable customers (Verhoef and Donkers 2001, p.189).

The strategic perspective of relationship marketing stresses the idea that resources intended for developing, retaining or enhancing relationships should be distributed based on buyers' value to the sellers (Kracklauer et al. 2001; Tan et al. 2002). This standpoint recognises that not all buyers are equally valuable, hence maximum profitability can only be achieved when resources are invested in relationships with potentially good level of return (Ryals, 2003). Researchers who describe relationship marketing as a strategy also tend to stress that relationship marketing enables sellers to develop the "right" type of relationship with seller, which in certain case not to develop any relationship at all (Kracklauer et al. 2001; Verhoef and Donkers 2001). Therefore, relationship marketing is the concept which beliefs that buyers should be treated like most other investments or assets in which relationship marketing needs to be correctly managed by sellers in order to achieve maximum profits (Plakoyiannaki and Tzokas 2002; Ryals, 2003; Ryals and Knox, 2001).

Relationship Marketing as a Technological Tool

> [Relationship marketing] is the technology used to blend sales, marketing, and service information systems to build partnerships with customers (Shoemaker, 2001, p.178).

While the evolution of technology has helped in enhancing the relationship marketing concept (Winer, 2001), few (if any) relational marketers would agree that relationship marketing is just a technological tool to bridge relationships between sellers and buyers. Indeed, one of the most popular beliefs examined in literature is that "relationship marketing is more than a technological tool" (Chen and Popovich, 2003; Fairhust, 2001; Kotorov, 2003). According to Shoemaker (2001), relationship marketing enables sellers to use technology, as one of key strategic resources, to implement the quality and type of desired seller-buyer relationships. By utilising the advancement of technology, sellers could better comprehend their buyers' needs such as buyers' preferences toward the relationships (Shoemaker, 2011).

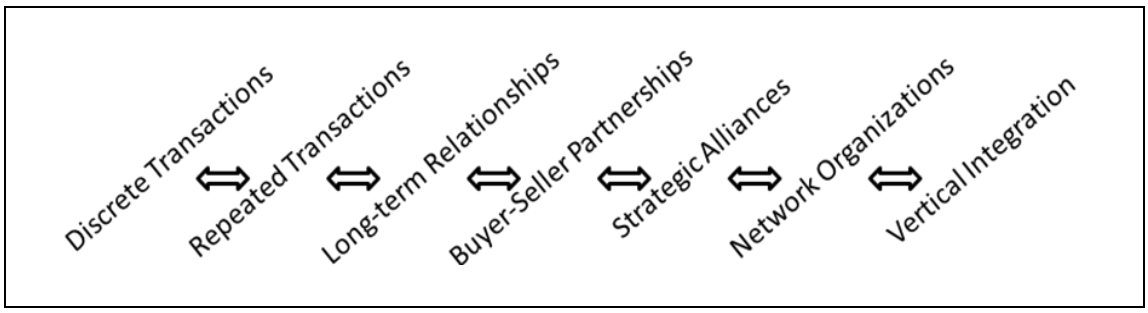
Relationship Marketing Definition

For the purpose of this study, relationship marketing is defined as: The continuous strategy of engaging in collaborative and cooperative activities with the purpose of improving mutual economic value using long-term technological tool which intentionally aim to develop, maintain or enhance the relationship. Without having profitable as one of the aspects of interaction between businesses, the seller-buyer relationship could easily unleash. Hence, it is essential for sellers to appreciate the value of each buyer and focus on buyers who give high potential return.

RELATIONSHIP MARKETING IN B2B CONTEXT

Relationship marketing comes in many different forms (Egan, 2011). In general, relationship marketing can be divided into two groups which are 1) business-to-consumer (B2C), relationships associate with consumer goods and services, and 2) business-to-business (B2B), relationships often relate to the link of supply chain (Egan, 2011). This section will further explore the relationship marketing in the context of B2B. Håkansson and Snehota (1989, p.187) stated that 'no business is an island' when it comes to businesses especially in the B2B context. In other words, most businesses in the B2B market are interdependence among each other. For the past three decades, the trend illustrates that businesses have moved towards relational exchanges in order to achieve and maintain competitive advantages (Webster, 1992). According to Webster (1992), among many B2B relationship types, sellers may build long-term relationships, partnerships, strategic alliances, or network organisations, or vertical integration with their buyers. Sellers' willingness to enter the marketing relationships with buyers depends greatly upon sellers' expectation that the relationships will create or add value to the sellers (Day, 2000).

Figure 1 illustrates a range of marketing relationships, from discrete transactions to vertical integration, developed by Webster (1992). According to the researcher, as businesses (and the relationships) move along the continuum, the businesses have less market control based upon price but more administrative and bureaucratic controls.



Source: *Adopted from Webster (1992).*

Figure 1. Range of marketing relationships.

Discrete Transactional Exchange

Discrete transactional exchange, the least form of relationships, is for money exchange which is an easy form of commodity (Webster, 1992). Each event in discrete transactional exchange is treated independently because price itself guides the exchange. The price is determined by the marketplace and there is no past or anticipate future transaction between a seller and a buyer. In discrete transactional exchange, a service or product is viewed as commodity in which "there is no brand name, no recognition of the customer by the seller, no credit extension, no preference, no loyalty, and no differentiation of one's producer's output from that of another" (Webster, 1992, p.6). The discrete transactional exchange is relatively more challenging than other relationship exchanges because both sellers and buyers in discrete transactional exchange will have to strive in order to achieve best competitive advantage (Webster, 1992).

Even though true discrete transactional exchanges are definable in theory, pure discrete transactional exchange is less common compared to repeated transactional exchanges and other relational exchanges. Repeated transaction businesses are businesses with at least one previous exchange between seller and buyer (Webster, 1992), and other relational exchange businesses are businesses whereby each of their transactions is a portion of past and future transactions (MacNeil, 1980). Between these transactional and relational exchange business extremes, are increase in time and history, increase in power of one party, increase in both explicit and implicit trust, increase in contractual agreement, increase in joint planning, increase in involvement of multiple parties, and increases in seller-buyer communication and participation (Dwyer, Schurr, and Oh, 1987). Relational exchange businesses may also engage in social exchange and encounter non-economic satisfactions.

Relational Exchanges

Realising that the success of businesses in the B2B market depends greatly on the collaboration and cooperation between sellers and buyers, many businesses are moving away from discrete transactional exchanges. The current competitive B2B environment has also encouraged businesses to move toward relationship oriented approach (Grönroos, 1994). Even though Webster's (1992) continuum does not clearly detail where the relationship marketing should commence and end, it is implied that the relational exchange businesses stretch from long-term relationships to vertical integration (see Figure 1). That means, relational exchanges include long-term relationships, buyer-seller partnerships, strategic alliances, network organisations, and vertical integration.

WEB 2.0 AND SOCIAL MEDIA

This section discusses another mainstream of literature relating to web 2.0 and social media. The discussion includes two sections which are presented in the following order: 1) the evolution of web 2.0 and 2) users' attitudes towards social media.

The Evolution of Web 2.0 and Social Media

Social media signifies an evolution of web technologies from web 1.0 to web 2.0. The web 2.0 refers to the new generation of web which has become known as a more social, participative, and open environment (Ravenscroft, 2009). Web 1.0 is usually described as a controlled environment with only few administrators who understand or have knowledge about the web mechanism, and many others who have limited roles in its management or creation (Mills-Board and Carr, 2003). Web 2.0, on the other hand, is defined as architecture of participation (O'Reilly, 2007). The term 'web 2.0' was first introduced in a conference in 2004. The term was introduced to illustrate the new approach or platform for consumers and software developers in which its applications and contents are not created or published by selected individuals but are continuously modified by everyone in a self-participatory and collaborative manner (Kaplan and Haenlein, 2010; O'Reilly, 2007). Web 2.0 comprises of social networking, tagging, virtual worlds, wikis, and many other applications (Majchrzak, 2009).

Users' Attitudes towards Social Media

According to Stenmark (2008) web 2.0 is not about the technology only. The researcher argued that the emergence of web 2.0 also relates to users' attitudes towards social media. In this perspective, web 2.0 can be categorised into two groups of users' attitudes which are 1) attitude toward information ownership, and 2) attitude toward productivity versus creativity. Social media enables information to be formed through interactions of end-users. According to Stenmark (2008), web 2.0 gives ownership and control over information to users and thus breaks away central control by administrators. Building on Ciborra (2000) belief that information within organization is often tightly managed by top management, Stenmark (2006) concludes that information needs to be centrally administered in order to be valuable to the organisation. Social media, however, is based on entirely different norms where it builds on trust in users' ability to self control (Stenmark, 2008). Thus, social media enables information to be created by users and hence to be owned by the users (Stenmark, 2008).

Users' attitude towards information ownership is closely related to users' attitude towards productivity versus creativity. According to Stenmark (2008), early adopters of information technology were able to increase their productivity and thus achieve competitive advantages. Today, however, productivity is no longer the ultimate driving force for business, but creativity is (Stenmark, 2008). It has been debated for more than a decade that the competitiveness of a business does not depends greatly on its ability to exploit old concepts, but on its ability to continuously adapt to the dynamic environment, create innovative ideas, and develop new products (Kay, 1993). The evolution of web 2.0 technologies and social media has promoted businesses to strive not only for productivity, but also for creativity, and innovation (Andriole, 2010; Stenmark, 2008). To further illustrate, with the existent of blog and wiki technological tools, businesses are now able to crowdsource or gather information from many users within and outside their boundaries (Andriole, 2010).

In general, web 2.0 offers a platform for the development of social media (Kaplan and Haenlein, 2010). Social media is defined as a set of internet-based applications which build on both ideological as well as technological foundations of web 2.0, and enabling the creation and modification of user-generated content (Kaplan and Haenlein, 2010). Gruber (2008) also described social media as a group of websites and applications in which participation among users is the main driver of value. Social media, which is now a major player in most businesses (Edosomwan et al., 2011), include blogs, micro-blogs, social networking sites, virtual worlds, collaborative projects, content community sites, and sites for feedback (Chan and Guillet, 2011).

RESEARCH FOCUS AND QUESTIONS

According to Pitt, van der Merwe, Berthon Salehi-Sangari, and Caruana (2006) the World Wide Web is becoming the most important medium for business-to-business (B2B) commerce. When it comes to relationships among businesses, marketers of B2B companies have started to utilise the web as one of the value-adding strategies (Sharma, 2002; Walters, 2008). Despite the increasing studies (i.e. Bauer, Grether, and Leach, 2002) pertaining the roles of the web in building B2B relationships, to date, there is still a lack of understanding of the roles of social media, especially in the area of B2B relationship marketing. The degree to which social media is used by businesses, especially based on the types of B2B marketing relationships, is also not well

understood in a comprehensive way. According to Michaelidou, Siamagka, Christodoulides (2011), anecdotal studies (i.e. Shih, 2009) indicate that social media too is important for B2B companies. Based on Cone's (2008) study, 93% of social media users think that businesses should at least have a social media presence. Business can utilise social media, such as Facebook, Twitter, YouTube, and LinkedIn (Jahn and Kunz, 2012; Shih, 2009) to interact with other businesses, develop relationships and trust, and to identify prospective partners (Shih, 2009). Given that the potential impacts of social media in a corporate environment is essential, knowledge about the role of social media in the B2B context is considered important for developing relationships among businesses (Enders et al., 2008; Kaplan and Haenlein, 2010). Yet, studies into social media are very limited, and emphasise more on the consumer of B2C rather than on B2B-type of businesses (Jussila, Kärkkäinen, and Leino, 2013). One of the possible reasons of this limitation is because B2B companies had been slower in adopting social media (Michaelidou, Siamagka, Christodoulides, 2011) despite the fact that B2B related e-commerce is worth at least three and half times more than that of B2C related e-commerce (Kalapesi, Willersdorf, and Zwillenberg, 2010). Therefore, the main objectives of this study are to explore the role of social media in the area of B2B relationship marketing as well as to understand the extent to which social media are represented through the types of B2B marketing relationships.

The emergence of web 2.0 and social media technological tools has led to the enormous number of social media on the web. As of 2009, social networking sites alone consists of more than 150 sites on the web (NielsenWire, 2010), and among all of the social media users, 85% of them believe that businesses should interact with their consumers through social networking sites (Cone, 2008). Even though businesses have now started to penetrate the online social networks and offer direct links from corporate websites to social networks like Facebook and Twitter (Kaplan and Haenlein, 2010), there is still little known on what types of social media businesses use in developing B2B marketing relationships. Thus, the following research question is derived:

R1: What types of social media do businesses use in B2B relationship marketing?

Even though the evolution of social media has given rise to how businesses can leverage social media in order to support their marketing efforts (Gretzel, 2006), there is a scarcity of knowledge of how social media are used by businesses particularly in a B2B environment (Michaelidou, Siamagka, Christodoulides, 2011). According to Stenmark (2008), the technological tools used to utilise social media in a corporate environment are similar to that of public setting. Yet, there are and have always been huge differences in how the social media has been utilised in a business setting (Fagin et al., 2003). It is argued that one of the reasons to these differences is due to the diverse cultures and attitudes which exist between business world and the society as a whole (Stenmark, 2008). Compare to other environments, the corporate environment has always put more emphasis on a tight policy control by the top management (Ciborra, 2000). The nature of a business is less democracy with information ownership has traditionally taken a top-down approach (Stenmark, 2008). However, the setting of the public net, including social media, has always been bottom-up driven (Stenmark, 2008) and information ownership has always been dominated by the users (Mangold and Faulds, 2009). Therefore, the utilisation of social media in a business environment may not merely conforming to the utilisation of social media in the public setting. This study

also aims to explore how businesses use social media in developing B2B relationship marketing, hence the following research question is developed:

R2: How do businesses use social media in B2B relationship marketing?

Social media is used in various degrees in different business functions such as in branding, information sharing (Brennan and Croft, 2012), public relations, understanding customers, lead generation, collaborative work, internal communication, and sales support (Gordon, 2009). Research shows that information sharing, public relations, and collaborative work are among the business functions which are used more actively than the internal communication function (Gordon, 2009). In other words, companies use social media less actively for internal purposes than for collaboration with other businesses or partners. Yet, according to Kärkkäinen, Jussila, Väisänen (2010), the adoption of social media among companies, especially B2B-typed of companies, remain in the infancies. Compare to B2C companies, B2B companies use social media less despite the fact that social media was allowed more often in B2B companies compare to in B2C companies (Kärkkäinen, Jussila, Väisänen, 2010). Among the few reasons of slow social media adoption by B2B-typed of companies (Michaelidou, Siamagka, Christodoulides, 2011) include the lack of understanding the possibilities of social media, difficulties of assessing the financial gains from social media, difficulties in adopting new mental models and practices needed for the adoption, and lack of evidence of similar cases using social media (Kärkkäinen, Jussila, Väisänen, 2010). Even though studies illustrate that there are many possible reasons of slow social media adoption among B2B-typed of companies, to date, there are still limited studies pertaining the reasons why businesses use social media especially in B2B relationship marketing. Studies relating to when do businesses use social media, such as but not limited to when developing, maintaining or enhancing B2B relationship marketing, are also not well understood. Hence, the following research questions are created:

R3: Why do businesses use social media in B2B relationship marketing?

R4: When do businesses use social media in B2B relationship marketing?

METHODOLOGY AND METHODS

In order to accomplish the objective of this research and answer the research questions, this study will be adopting a qualitative method approach. The current research is an exploratory in nature. Specifically, an in depth semi-structured interviewing technique will be performed given that the area of this study is a new and under-research topic (Dick, 1990). A range of 20 - 25 interviews, each with 30 to 60 minutes of length, will be executed to individuals who work in the business relation related fields. The participants of this study will be asked to answer several questions regarding the utilisations of social media, specifically in the perspective of B2B relationship marketing.

Qualitative Study

A qualitative research is an inductive research method generally adopted by researchers to investigate and to understand unexplored phenomena (Carson and Coviello, 1996), and/or areas which are deficient in theory (Parkhe, 1993; Perry, 1998). The main strength of qualitative research techniques is in the ability to clarify problems. The flexibility and openness structure of qualitative methods allow researchers to explore and gather information which cannot be uncovered through the use of structured survey-based techniques (Aaker, et al., 2007).

In-depth Semi-structured Interview

An in-depth semi-structured interviewing technique is the preferred method since the technique allows researchers to get closer to the participants' perspectives (Denzin and Lincoln, 1994). Lee (1993) specifically refers to in-depth or unstructured interviews as providing the technique of getting beyond surface appearances and permitting larger sensitivity to the meaning of contexts surrounding informant responds and expressions. Semi-structured interviews may have similar impact if sufficient scope is given to exploration of interviewee comments.

CONCLUSION

This paper serves as an introduction to the study. This paper has given background information about the research topic, and identified the research focus and questions in the literature. The relevant literature was also presented, followed by the research methodology and methods.

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BIOREMEDIATION FOR ACID MINE DRAINAGE: ORGANIC SOLID WASTE AS CARBON SOURCES FOR SULFATE-REDUCING BACTERIA: A REVIEW

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ABSTRACT

Biological sulfate reduction has slowly replacing chemical unit processes to treat acid mine drainage (AMD). Bioremediations for AMD treatment are favored due to low capital and maintenance cost. This paper mentions on available AMD treatment, current SRB commercialization such as THIOPAQ® and BioSulphide® technologies, and also factors and limitations faced. THIOPAQ® and BioSulphide® technologies are using expensive carbon sources such as hydrogen as electron donor. This paper discussed on the possibility of organic solid waste as alternative substrate as they are cheaper and abundant. A possible AMD treatment system set-up was also proposed to test the efficiency of sulfate-reducing bacteria utilizing organic solid substrate.

Keywords: Acid mine drainage; biological treatment; bioremediation; sulfate-reducing bacteria; carbon source.

INTRODUCTION

A substantial number of investigations have been done by various institutes, private companies and universities regarding the development of biological process for the application in the mining and metallurgical industry (van Houten, Pol, & Lettinga, 1994). These investigations mainly focus in treating AMD wastewater formed in mining and metallurgical industries. In recent years, improvements have been made in designs, constructions and operation of aerobic and anaerobic bioreactors for bioremediation to treat AMD. Bioremediation in mine treatment was ignited due to waste management and handling, especially in the urban world. In recent years, global awareness on environmental effect has increased due to the depletion of valuable and non-renewable resources. In response, some local government has taken their own initiatives to improve waste management and handling. An example of these initiatives can be seen with the *Waste Reduction and Recycling Bill 20011* by the Queensland State Government. This bill requires the waste management operators to practice under a new pricing regime of $35 per ton of waste received (Q. S. Government, 2011).

One of the sources of AMD is from the by-product of metal mines or coal mines, and it occurs when sulfide-bearing material is exposed to oxygen and water. This is one of the major environmental issues associated with the mining industries. The effluent generated from metallurgy mines contain toxic substances such as heavy metals and cyanides in abundant amount (Akcil & Koldas, 2006). AMD can be characterized by having low pH and high concentration of heavy metals and other toxic substance, which can cause severe surface and ground water contamination (Peppas, Komnitsas, & Halikia, 2000). AMD characteristics differ from site to site due to the availability of

different minerals (A. Government, 2007). Pollution control of AMD is achievable by preventing AMD formation, migration and/or collection treatment (Kaksonen & Puhakka, 2007). This review is an overview to identify the knowledge gaps in bioremediation of acid mine drainage (AMD) where organic solid waste as well as municipal solid waste to be considered as alternative substrates or carbon sources.

ACID MINE DRAINAGE TREATMENTS

A collection and treatment method is the key factor in management and control strategy used in AMD treatment. This strategy consist on the collection of all contaminated mine waster and will be treated by either chemical or biological process, where it aims at neutralizing the acidity, removal of metal species, and suspended solids. A traditional method for treating AMD consists of neutralizing the acidity with alkali, increasing water pH, and precipitate metals as hydroxides and carbonates. Other treatments include ion exchange, reverse osmosis and electro-dialysis, but were not preferred as its high operational costs. Biological treatment for sulfate reduction is gradually replacing the chemical unit treatment. Biological treatment, or also known as bioremediation, employs sulfate-reducing bacteria (SRB) to treat ground as surface water contaminated by AMD. SRB are able to produce biogenic H_2S, which would be used to react with heavy metals, resulting in the precipitation of metal sulfides. Biogenic alkalinity is also a by-product by SRB, which is used to neutralize acidic water. Bioremediation can be classified into passive biological treatment and active biological treatment, and Table 1 describes a brief summary of these treatments.

Table 1. Comparison between passive and active treatment.

METHOD	PASSIVE	ACTIVE
Cost	Low	High
Need of labor	Small	High
Treatment area	Large	Small
Metal recovery	Difficult	Easy
Control	Poor	Good
Predictability	Poor	Good

This paper will be looking into active biological treatment and the current commercialization of this treatment. Table 2 represents a summary of the advantages and disadvantages of various reactor types that can be applied in this research. Active treatment system is typically a continuous process and involves at least one reactor. This allows a precise process control and this system also allows modifications of functions in a biological system. One of the set back of bioremediation is that the start-up of a biological reactor system is harder than the conventional chemical process treatment. The mechanisms of biological system are currently not fully understood, thus the fundamental knowledge regarding the microbial community and key parameters are needed for the improvement of this treatment.

Table 2. Summary of various reactor configurations.

Reactor Configuration	Advantages	Disadvantages
Continuous stirred tank reactor(CSTR)	• Consistent, reliable and rapid equilibrium conditions	• Poor retention of biomass
Anaerobic contact process (ACP)	• Better retention of biomass compared to CSTR	• Pumping of biomass breaks down flocks and sludge
Anaerobic filter reactor	• Low shear forces • Longer sludge retention time • Down-flow gravitational mode	• Pressure gradient built-up
Fluidized-bed reactor	• Large surface area for SRB growth • High retention of biomass • Small pressure gradients • Dilute influent concentrations due to recycle flow	• Energy needed for carrier fluidization • Detaching of biomass due to shear force • Less volume available for biomass compared to UASB reactor
Up-flow anaerobic sludge blanket reactor (UASB)	• No channeling of flow • No compacting of sludge • No clogging • Possibility to obtain high treatment rates	• Biomass flush out

Hydrogen sulfide (H_2S)

Hydrogen sulfide (H_2S) is applied in the mining industry for metal sulfide precipitation. The synthesis of H_2S can be classified into four main chemical mechanisms, but the most preferred method would be by sparging hydrogen (H_2) through liquid sulfur (S). Kwinana nickel factory in Australia was able to produce 4.4 tonnes per day of H_2S through this method for nickel extraction processes (Warren, Lee, Morey, & Zaninovich, 2009). Hydrogen sulfide is toxic and lethal when exposed, making the transportation of H_2S to the mining site restricted and costly. An on-site plant production of H_2S would be an ideal solution to overcome these limitations, such as the plant in Kwinana nickel factory.

FACTORS AND LIMITATION OF BIOREACTOR SYSTEM PERFORMANCE

This section highlights the key parameters that can affect the overall performance and the efficiency of the bioreactor system.

Sulfate-reducing bacteria

Sulfate-reducing bacteria (SRB) utilize organic carbon for sulfate reduction, while generating biogenic H_2S and alkalinity. Eq. (1) below describes the mechanism for sulfate reduction by SRB where CH_2O represents organic carbon.

$$2\,H^+ + 2\,CH_2O + SO_4^{2-} \rightarrow\ H_2S + 2\,H_2CO_3 \quad (1)$$

This resulted in the precipitation of heavy metals in AMD and an increase in pH and alkalinity. Biogenic H_2S will then react with metallic ions (Me^{2+}) present in AMD and forms metal sulfides (MeS), while hydroxide ions (HCO_3^-) will react with protons (H^+) to neutralize acidic waters which are explained in equation below (Kaksonen & Puhakka, 2007):

$$Me^{2+} + HS^- \rightarrow MeS + H^+ \quad (2)$$
$$HCO_3^- + H^+ \rightarrow\ CO_2 + H_2O \quad (3)$$

The expected result in sulfate-reducing environment will include a decrease in sulfate concentration and heavy metals, while and in increase in pH and alkalinity (Benner, Blowes, Gould, Herbert, & Ptacek, 1999; Hulshof, Blowes, Ptacek, & Gould, 2003).

Microbial community structure

Sulfate-reducing bacteria alone are not capable of oxidizing complex organic compounds and require help from other microbial communities to breakdown complex sugar to a simpler form for SRB consumption. There are several types of microbial proponents that act in synergism within the system, which are methanogens, acetogens and sulfate reducers (Neculita, Zagury, & Bussière, 2007). Competitions between micro-organisms for available fermentation products are inevitable. However, based on the thermodynamic analysis, SRB are expected to outcompete the acetogens and methanogens for carbon source, provided that sulfate is in excess.

pH

Sulfate-reducing bacteria favors a pH range between 6.8-7.2 for optimal growth as pH below 5 may inhibit the sulfate process (Lu et al., 2011). However, if a significant production of H_2S is to consider, a pH range of 5 to 6 must be in order to ensure maximum H_2S production.

Organic substrate

Availability of carbon source is the critical limiting factor for SRB reaction. In AMD water, the carbon source is limited and requires additional or external carbon sources for a successful treatment (Kolmert, Wikström, & Hallberg, 2000). Sulfate reduction is an energy intensive process, which requires a considerable amount of energy-rich reductant (Martins, Faleiro, Barros, Veríssimo, & Costa, 2009). Hence, selection of suitable carbon sources for bioremediation technology will have an impact on its efficiency and economical viability.

Organic matter composition must be considered as it determines the SRB eco-technology effectiveness (Gibert, de Pablo, Cortina, & Ayora, 2002). A substrate must be able to create suitable low redox environment while serving readily-available carbon source. A mixture of readily biodegradable materials with multiple organic carbon sources are more effective to be create longevity and sustainability of microbial communities (Neculita et al., 2007; Sheoran, Sheoran, & Choudhary, 2010).

Direct vs. Indirect Organic Substrate

Simple form of organic substrates are preferred by SRB as food source and it can be supplied either direct or indirect method. Direct organic sources such as alcohols, organic acids and sugars, are readily available for SRB consumption without having to further decompose it. Meanwhile, indirect organic sources such as organic compost, wood or paper waste, and food production by-product require further degradation to produce desired product. As mining sites are located far from urban areas, indirect substrate would be more suitable in long term situations compared to direct organic substrate (Sheoran et al., 2010). Even though relatively simple substrates have the advantages of providing a quick and direct utilization of energy sources by SRB, it has the tendency to be used up quickly. Indirectly, substrates will be required to be continuously fed into the system, thus increasing the operational cost and maintenance (Hiibel et al., 2011).

Hydraulic Retention Time

Hydraulic retention time (HRT) between 3-5 days has been accepted to allow sufficient time for sulfide metals to precipitate for direct organic substrate. However, doubling the HRT to 7-10 days has been suggested for indirect organic substrate to allow sufficient time for microbial growth (Alvarez, Crespo, & Mattiasson, 2007; Chang, Shin, & Kim, 2000; Gonçalves, Oliveira Mello, & Costa, 2008).

Temperature

SRB includes both mesophilic and thermophilic strains and are able to survive a temperature range between -5 to 75 ^{o}C. Temperature may severely affect the growth and sulfate reduction kinetics of SRB (Tang, Baskaran, & Nemati, 2009). Sulfate-reducing bacteria performance depended on the activity of other anaerobic bacteria to degrade complex organic substrate to simple form. Furthermore, methanogens are sensitive to low temperatures and prefers a mesophilic condition for growth. Therefore, it would be expected that production of biogenic H_2S will vary with season.

Solid support

Addition of solid support for SRB may provide positive effects for bacteria growth, thus indirectly increase the precipitation of metals. Among materials that have been suggested for solid support includes sand, gravel and glass beads (Alvarez et al., 2007; Choudhary & Sheoran, 2011; Hulshof et al., 2003). It was preferred to select the solid support that has large pore size, low surface area and large volume of solids to reduce plugging in the bioreactor (Sheoran et al., 2010).

Inhibitory effect

High concentration of metallic ions such as iron, zinc, copper and manganese in AMD are toxic and can inhibit the growth of SRB. It has been reported that the lethal range of metallic ions to SRB communities are at: 2-50 mg Cu/L, 13-40 mg Zn/L, 75-125 mg Pb/L, 4-54 mg Cd/L, 10-20 mg Ni/L, 60 mg Cr/L, 74 mg Hg/L (Tang et al., 2009). However, these ranges may vary and are dependent on the species of available SRB. The inhibitory effect increases in the following order:

Sulfate < Thiosulphate < Sulphite < Total sulfide < H_2S

BIOGENIC H_2S PRECEDENT

Biogenic H_2S productions in metallurgical process industry have been successfully tested for commercialization.

Copper Queen Mine, Bisbee, Arizona

A copper plant recovery from low grade leach solution at Copper Queen Mine in Bisbee, Arizona, has been utilizing BiotecQ's BioSulphide® process technology. This plant uses high rate anaerobic biotechnology for on-site production of H_2S from elemental sulfur. The biogenic sulfide produced was used to precipitate copper into a high-grade copper sulfide from pregnant leach solution (PLS) draining from low grade stockpile (2008).

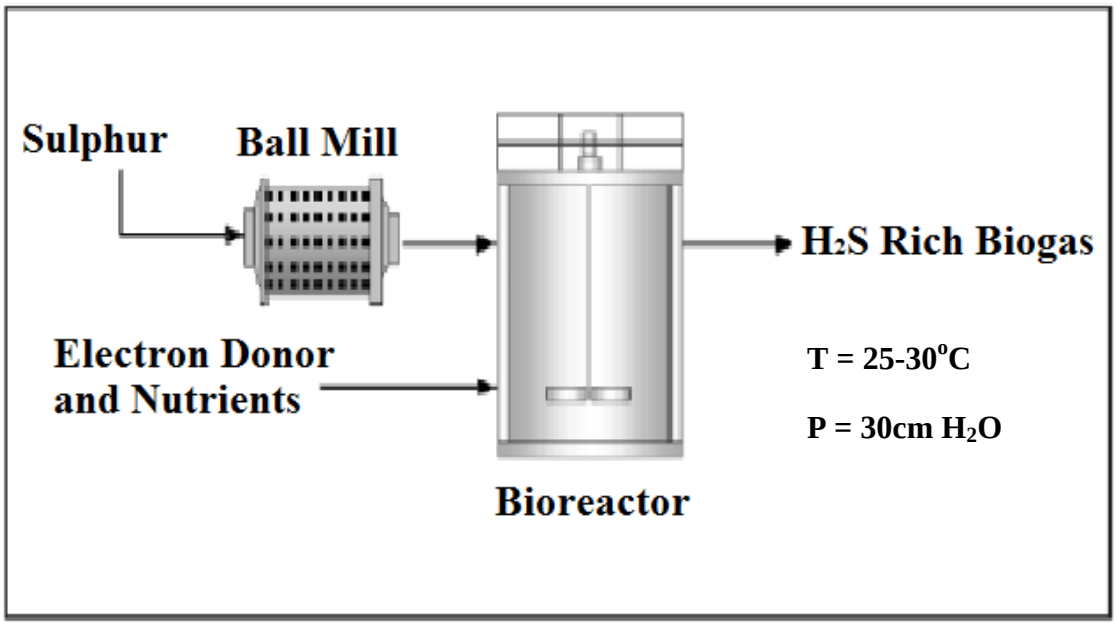

Figure 1. Bisbee PLS composition (Ashe et al., 2008).

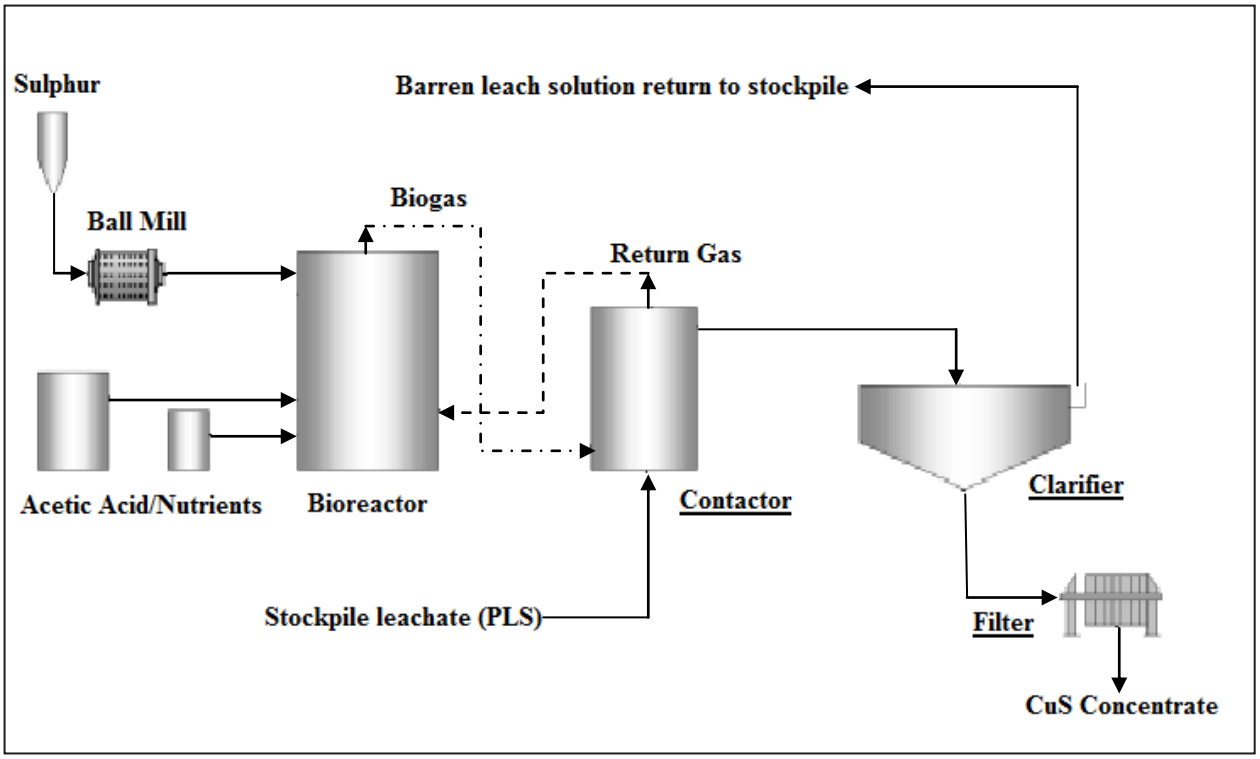

Figure 2. BioSulphide® process in Bisbee (Ashe et al., 2008).

The plant was design to treat 2000 gpm of pregnant leach solution (PLS). Figure 1 shows the typical composition of PLS in Bisbee plant, and a simplified flow sheet of the sulfide plant at Bisbee is shown in Figure 2. The plant which comprises a bioreactor was design to have the production capacity of 3.4 tonnes f H_2S per day. The sulfide gas is then passed to an agitated contactor tank where it is mixed with PLS to precipitate copper.

Overall annual maintenance cost to operate the plant is approximately $135,000/year, which is roughly about 4% of the original capital cost. In the first 2 years of operation, the plant had recovered on average 63,502 kg/month of copper from low grade stock-pile. The Bisbee plant has been reported to produce sulfides between 50 kg/day to 3.7 tonnes/day (N.L. Ashe et al., 2008).

Kennecott Utah Copper (KUC), Bingham Canyon, Utah

Kennecott Utah Copper (KUC) operates a vast, integrated mine-mill-smelter refinery complex in Bingham Canyon, Utah, and was reportedly to produce over 270 kilotonnes of copper annually (van Lier, Buisman, & Piret, 1999). A demonstration plant was develop by a joint venture between PAQUES and Kennecott to asses THIOPAQ® sulfate and metal removing technology using hydrogen as the electron donor. The demonstration plant was equipped with a 5 m^3 hydrogen reactor and was divided into two sections which are the biological H_2S production, and copper recovery from leach water.

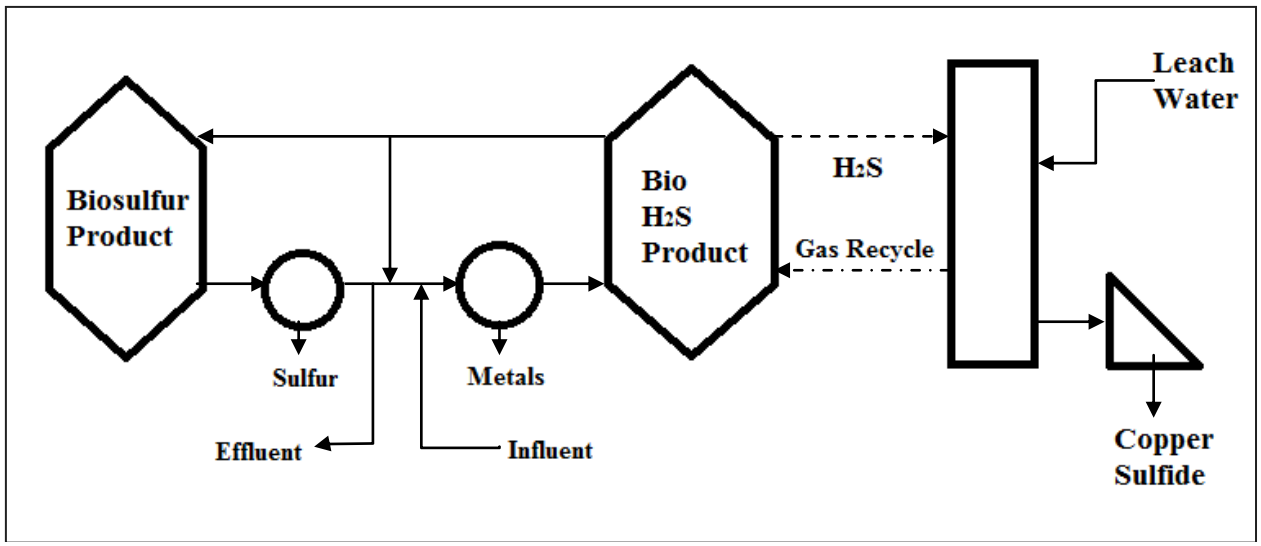

Figure 3. THIOPAQ® demonstration plant at Kennecott (van Lier et al., 1999)

THIOPAQ® technology was able to reduce significant metal and sulfate concentrations, while increasing the pH solution from 2.5 to 8.5 without any addition of alkaline. The biogenic H_2S gas produced was used for selective recovery of copper from dilute leach water stream currently treated by cementation and the copper recovery was almost 99.8%.(van Lier et al., 1999)

BIOGENIC H_2S PRODUCTION

Biological process production of H_2S has lower capital cost when compared to chemical process. This significant cost reduction is due to biological plant uses ambient temperature and pressure in conventional stirred tank bioreactors to produce H_2S instead of pressure vessels with expensive agitator seals. The cost of construction of the copper recovery plant in Bisbee was approximately US$ 3.2 Million (N.L. Ashe et al., 2008). It was reported that the net profits from plant operations and copper sales allowed capital payback in less than 3 years (Nelson L. Ashe, McLean, & Nodwell, 2008).

Biogenic H_2S production from organic waste

Commercial biogenic H_2S production such as the THIOPAQ® and BioSulphide® technologies utilizes hydrogen, alcohol and acetic acid as carbon sources. These sources are readily utilized by SRB, yielding high H_2S in short amount of time. However, these sources are expensive and require a large amount for long term operation, which would put a strain on operational costs.

There has been several published reports that utilizes various organic solid wastes as the carbon source for SRB; which includes wood dust, oak chips and sludge from a wastepaper recycling plant(Goncalves, Mello, & da Costa, 2007). These waste materials have the advantage to be able to sustain the growth of SRB for long periods without the addition of other substrates.

Table 3. Summary on organic waste as substrate (Gibert et al., 2002).

Source of organic matter	System	Sulfate conc. (ppm)	T_R (days)	Additional carbon source	Sulfide production rate (mg/(L.d))	Reference
SRB culture, cow manure, batch whey	Batch	1000	-	None	1-1.5 (total produced) 0 – 0.63 (effl. Content)	(Christensen, Laake, & Lien, 1996)
Creek sediment, vegetable compost, limestone	Column	100/500	0.6	Acetate	6	Not published
Mushroom compost	Continuous bioreactor, sulfide recirculation	n.a.	4.1	Lactate	413	(Hammack, Edenborn, & Dvorak, 1994)
Leaf compost, pea gravel, limestone	Full-scale PBR barrier	n.a.	6	None	3.7	(Ludwig, McGregor, Blowes, Benner, & Mountjoy, 2002)
Municipal solid waste	Batch	n.a.	180	None	1.5	(McCullough & Lund, 2011)
Sugarcane	Bench-scale FBR	n.a.	20	lactate	22.2	(Choudhary & Sheoran, 2011)

Waste material that contained polysaccharide seemed to be degraded by hydrolytic fermentative anaerobes to fatty acids and alcohols that support the growth of the sulfidogens (Chang et al., 2000). Another study showed success in metal precipitation using biogenic H_2S from volatile fatty acids through microbial hydrolysis of papaya, apple and banana (Alvarez et al., 2007). Table 3 represents a summary of the performance of organic waste in sulfide production.

REVIEW OUTCOME AND RECOMMENDATIONS

Research gaps on municipal solid waste as potential substrate

Although there have been many reports utilizing organic solid waste as carbon source for SRB, (Choudhary & Sheoran, 2011; Gonçalves et al., 2008; Martins et al., 2009) most of these reports were based on batch process. There have been some successful studies that performed in continuous culture for sulfide production; however it was

reported that direct or simple carbon source such as ethanol and acetic acid was used instead of a complex organic waste (Alvarez et al., 2007; N.L. Ashe et al., 2008). Municipal solid waste (MSW) potential as alternative substrate has not been fully understood especially in continuous process, creating a knowledge gap in understanding the organic waste performance. Municipal solid from green waste showed low sulfide production rate than other wastes. Further research will be required to study H_2S production using municipal solid waste as potential substrate for SRB.

Possible bioreactor system configuration

A possible schematic diagram of a bench-scale sulfide treatment system is shown in Figure 4. The system may consist of three different components which include bioreactor, chemical reactor and alkaline reactor. The bioreactor will be in anaerobic condition and the environmental condition will be designed to favor the growth and development of SRB. Reaction between SRB and carbon source in bioreactor produces biogenic alkalinity and sulfide ions (HS^- and S^{2-}). Afterwards, a recirculating gas stream from bioreactor will be used to sparge H_2S from bioreactor into chemical reactor where AMD waters will be pumped into it as well. Meanwhile, the effluent water from the chemical reactor will flow through alkaline reactor to increase the pH to approximately 6 where the effluent will flow back into the bioreactor.

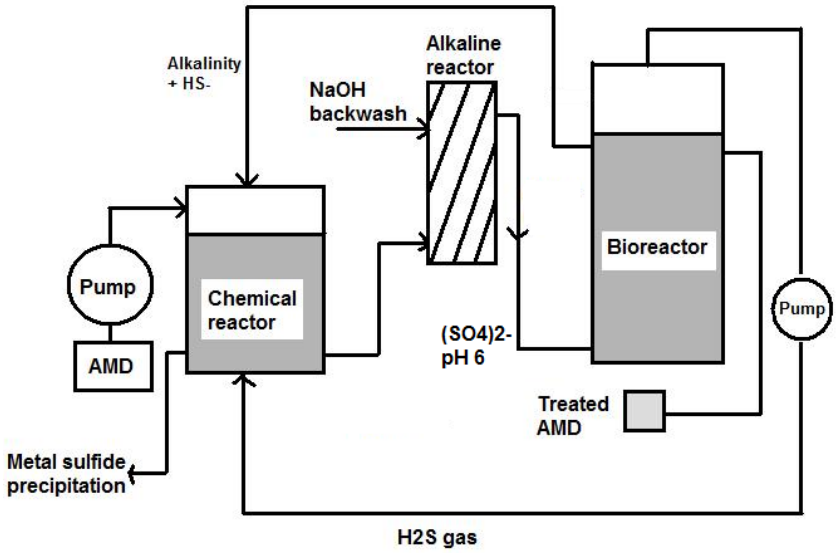

Figure 4. Schematic diagram for sulfide treatment system.

The medium in the bioreactor will be depleted in heavy metals, contained sulfate, and has an optimal pH to favor the bacterial growth. The final effluent from the treatment will be left through a U-shaped gas trap at the top of the bioreactor. The system will be tested the performance of the system when the HRT and flow rate are varied. Bioreactors are recommended to be inoculated and allowed to mature before AMD is fed in to provide long-term provision of organic carbon (Neculita et al., 2007). The suggested configuration of bioreactor system in Figure 4 was adapted from previous study done by McCullough et al.,(2011). Among the improvement suggested is upgrading from a batch to continuous process, and the separation of biological and chemical reactor.

Demonstration plants such as in Bisbee and Kennecott utilizes the BioSulphide® and THIOPAQ® technology demonstrates that continuous production of H_2S is viable given that the carbon sources are being supplied at a constant rate. By applying continuous process in the system showed in Figure 4, it is expected that the system will be able to produce a continuous supply of H_2S, resulting in an optimal recovery of metal sulfides precipitates. Furthermore, by improving the design with the separation of the reactors provide viable environment for the SRB community for growth activity. Inhibition of the SRB is avoidable since no metallic ions are introduced into the biological reactor. In addition, it is easier to control or change any parameters to the biological reactor with the separation of the chambers. Extracting process of the precious metal sulfides will be less of a hassle since SRB and metal sulfides are contained in different chambers. This ensures the SRB are present in abundant within the system, eliminating in lag and set back on the production of H_2S should SRB are accidentally flushed out of the system. In all, these improvements are expected to give further advantages for this study especially in creating sustainable system while producing maximum amount of H_2S.

Amount of waste required

By referring to the amount of H_2S generated daily in Copper Queen Mine, Bisbee (N.L. Ashe et al., 2008) and Equation 1, theoretically 5.83 tonnes of municipal solid waste per day will be required to produce 3.7 tonnes of H_2S per day. This calculation was done with the assumption that SRB utilizes 100% of solid waste as carbon source. An example for the solid waste collection near mining areas is in Gladstone, Queensland. The municipal solid waste collected at the Benary landfill was 12,500 tonnes in the year 2008-2009 (Council, 2008-2009). The average collection received was of 34.25 tonnes per day. Since it is estimated that 5.83 tonnes of solid waste is required per day to generate 3.7 tonnes of H_2S per day, Benary landfill is able to meet the demand of the solid waste for large scale bioremediation of AMD. Recycling and reusing solid waste for bioremediation treatment o AMD can reduce negative impact on the environment.

CONCLUSION

Acid mine drainage causes environmental pollution and preventing the formation or the migration of AMD from its source is generally considered to be the preferred option. Research indicates that bioremediation of AMD that employs sulfate-reducing bacteria have been the subject of interest for many investigators. Previously, research areas have focused on liquid based substrates (e.g. lactate, ethanol) for sulfidogenic bioreactors. Nevertheless, solid substrate materials have the potential to be successful substrate supply for sulfate-reducing bacteria system. However, there is a limitation on understanding the behavior on SRB activity with a solid substrate material. The review was able to identify that the rate limiting factor in sulfate reduction by SRB is the degradation of the complex organics. The overall operational costs of a biological treatment plant are a combination of the system design and location of the plant, profits gained from metal recovery, substrate selection and the discharge criteria. Finding suitable low-cost substrate alternatives such as the use of food waste by-product and organic solid waste may increase the use of SRB technology.

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BIOMECHANICS STUDY IN SPRINT KAYAKING USING SIMULATOR AND ON-WATER MEASUREMENT INSTRUMENTATION: AN OVERVIEW

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ABSTRACT

The review presented here is to provide an overview of the research in sprint kayaking particularly in biomechanical aspect with reference to previous literature documentation which emphasize on the variables measured kinematically and kinetically in determining the paddling efficiency. Various studies have been done either in the laboratory setting using kayak ergometer or during on-water kayaking; however, there is a lack of comparison study between the two settings to ascertain the mechanical aspect of a stroke paddling motion which require more studies to be conducted especially for the on-water performance measurement. On top of that, instrumentation for kayak study in obtaining useful data have been designed and developed extensively to further support the performance analysis which is advancing in accordance with the technology. Combination of technology application and effective feedback presentation usage will further improve the performance of the kayakers with the useful analysis obtained.

***Keywords*:** Sprint kayaking; biomechanics; kayak ergometer; instrumentation.

INTRODUCTION

Kayak sprint racing is one of the disciplines of International Canoe Federation (ICF) canoeing event at World Championships or Olympic Games which is also known as flatwater racing. The races are held in the distances of 200m, 500m and 1000m on calm water with the designated straight lane courses. Sprint racing is a highly competitive competition as the kayakers race to their top optimal performance in the specified distance at the shortest time possible. As such, technique and skill acquisition have great importance because the kayakers need to tackle the hydrodynamic element in order to paddle efficiently besides being physically, physiologically, psychologically and tactically strong.

Kayak paddling is a type of continuous and closed skill with repetitive action from the start to the end of the race course. It is important for the kayakers to execute the paddling motion with efficient power application in developing a symmetrical propulsive force to produce the greatest kayak speed (Michael et al., 2012). Mechanical efficiency is a subject of interest for the researchers, coaches and athletes to determine what are the variables to work on in obtaining optimal performance or enhancing it. Analysis of kinematics and kinetics of kayaking are useful in providing information either for real-time or post-event feedback which will aid the process of learning and acquiring the technique more effectively.

Measurement of kinematic and kinetic data of kayaking through biomechanical analysis using the cinematography technique have been documented throughout the years since 1970's and is developing progressively with the application of videography technique and telemetry system in accordance with technology advancement (Robinson et al., 2002; Smith, 2010). Paddling ergometer is used frequently in the laboratory to simulate the natural environment of on-water paddling where the validity in physiology component has been validated by some researchers between the two settings (Larsson et al., 1988; van Someren & Oliver, 2002; van Someren et al., 2000) but very limited biomechanical comparison study to ascertain the mechanical condition (Begon et al., 2008; Fleming et al., 2012). Instrumentation both in kayak simulator and on-water paddling measurement have been developed extensively for kayak study by the researchers to further improve the process of data acquisition apart from verifying the accuracy, reliability and validity of the results obtained. The present paper intends to provide an overview of the biomechanical studies that have been done previously in sprint kayaking by discussing the variables used for assessment on the kayak simulator in laboratory and on-water kayaking performance measurement. In addition, the development of instrumentation in both settings will also be discussed for an insight on the application of technology for performance evaluation tools in kayaking.

SPRINT KAYAKING BIOMECHANICAL ANALYSIS TECHNIQUES

The paper focused on a review of some of the selected past studies done specifically in sprint kayaking event on biomechanics study involving the collection of kinematic and kinetic data in both the laboratory simulation setting and on-water kayaking performance. There is variability across the studies in terms of duration and intensity of paddling, on-water paddling distance, methodology and devices used for measurement kinematically and kinetically which in turns also affected how the data are selected for analysis. Nevertheless, information is still useful to complement the study of performance measurement tool in kayaking.

Various variables have been used to study the motion of paddling. Among the common parameters used in kinematic analysis were kayak velocity, paddle orientation and trajectory, blade tip velocity and displacement, body range of motion (shoulder, elbow, knee, trunk and pelvis), stroke timing and length of stroke (Begon et al., 2008; Fohanno et al., 2011; Limonta et al., 2010; Mann & Kearney, 1980; Plagenhoef, 1979; Sanders & Kendal, 1992). One of the most important findings for an effective dynamic paddling is the utilization of pelvis rotation which also increases the trunk rotation to generate more powerful subsequent strokes (Begon et al., 2010; Limonta et al., 2010). Fohanno et al. (2011) also obtained similar results in their study in comparing the effects of fixed and swivel seat where the usage of rotating seat increases pelvis rotation which then enhances the mediolateral displacements and velocities of the virtual blade-tips. This pattern of motion is a more efficient paddling execution physiologically according to Michael et al. (2010), by applying the major trunk muscle group for a greater power output production using the stored energy.

Kinetic analysis in kayaking consisted of force data from the paddling stroke, and the contact forces between the kayakers and the ergometer which is in relation to forces exerted on the seat and footrest (Begon, Colloud, et al., 2009; Brown et al., 2010; Fleming et al., 2012; Michael et al., 2012; Rottenbacher et al., 2011). Observation of peak force during a stroke cycle showed that it was greater during the draw phase of the stroke (Fleming et al., 2012). A large different pattern of force profiles between the elite

kayakers is detected (Michael et al., 2012; Rottenbacher et al., 2011) and as such, Michael et al. (2012) suggested that the sustaining of work output is more important than the peak force value itself in order to generate a more efficient longer lasting paddling performance. Begon, Colloud, et al. (2009) on the other hand, found that the force exerted on the footrest also contributed towards pelvis rotation especially kayakers who used the foot strap which caused the seat force to decrease while paddle force increased. These show that the connection of lower limbs force production with the combination of pelvis and trunk rotation play an important role in producing a powerful efficient propulsion force through an appropriate co-ordination.

Sanders and Kendal (1992) proposed a qualitative model of the variables that are affecting the average kayak velocity. Based on their model, stroke frequency and stroke length were the two main contributors towards kayak velocity. Stroke frequency is the more obvious noted variable as the more skillful kayakers managed to achieve a better performance by minimizing the pull time and glide time (Brown et al., 2011; Sanders & Kendal, 1992) while Mann and Kearney (1980) concluded that drag force can be reduced with the shorter glide time. This is further supported by the correlation analysis done by McDonnell et al. (2013) recently based on the data of previous studies, where there was a high significant correlation of stroke time in relation to average kayak velocity specifically throughout the water phase time (time of entry, pull and exit). Plagenhoef (1979) suggested that the ideal division of one stroke according to phases would be made up of 22% (entry), 42% (pull), 5% (exit), and 31% (recovery) which require a further experimentation to also complete the deterministic model of correlation analysis of McDonnell et al. (2013).

DEVELOPMENT OF KAYAK ERGOMETER INSTRUMENTATION

Simulation of kayaking using ergometer in the laboratory is widely used in research for kayak performance study besides being a useful training tool especially when the weather is not permitting for outdoor kayaking. This has becomes an important issue not only to the researchers but also in the best interest of the coaches and kayakers as to whether the simulation will resemble the real situation as closely as possible apart from the various model of ergometer available, so that it does not deteriorates the performance due to different technique adaptation. The main components of a simulator in laboratory usually consists of an ergometer, a separate kayak seat with modified paddle and signal processing unit (Stothart et al., 1986a). There is an improvement of ergometer with flywheel braked by wind resistance to simulate water drag on the paddle blades (Larsson et al., 1988) progressing into ergometer with static frame on a moving trolley with elastic cord and availability of bungee cord tension adjustment to accommodate the increased stroke rate (Begon, Mourasse, et al., 2009), and lastly the implementation of wireless sensor system which enabled more mobile measurement process and minimize wired system (Sturm et al., 2010). This development is presented in Figure 1.

The kayakers were satisfied with the resemblance setting provided and Larsson et al. (1988) found that the maximal oxygen uptake (VO_2 max), heart rate and respiratory minute volume (VE) were similar to the values obtained during on-water kayaking, however, biomechanical analysis is not conducted. This is further supported through the findings by Páez et al. (2010) when they compared the level of significance between different ergometer with on-water performance and obtained high correlation values in heart rate, stroke rate and blood lactic acid concentration.

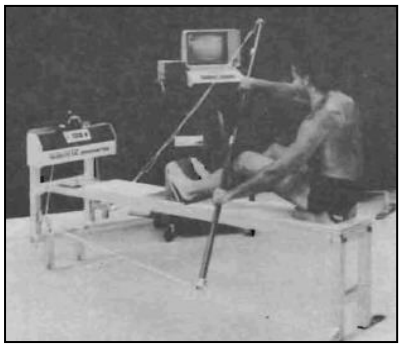
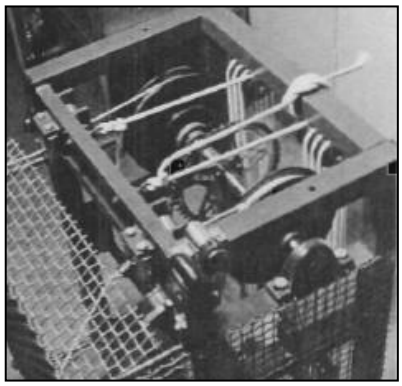
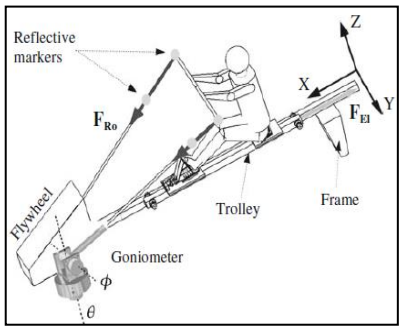
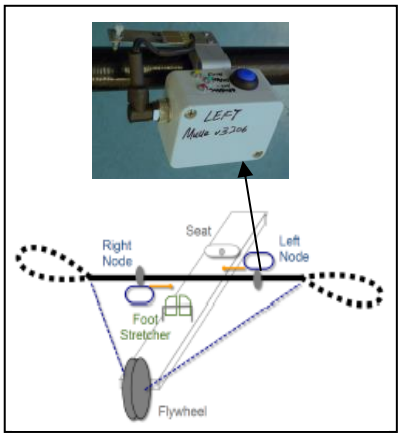
Stothart et al. (1986a)		Ergometer with separate kayak seat, modified paddle and signal processing unit
Larsson et al. (1988)		Ergometer with flywheel braked by wind resistance (simulate water drag on the paddle)
Begon, Mourasse, et al. (2009)		Ergometer with static frame on a moving trolley with elastic cord and bungee cord adjustment
Sturm et al. (2010)		Ergometer with the implementation of wireless sensor system

Figure 1. Development of kayak ergometer instrumentation

The inconsistency and lack of biomechanical aspect matching between simulated and on-water kayaking is addressed by Fleming et al. (2012). They found that

the rates of force development was greater during on-water kayaking compared to on-ergometer especially during the pull phase of the paddling stroke which they explained it might be caused by the pulling force of the flywheel against the paddle of the ergometer. A better improved mechanical design of kayak simulator with a combined usage of computer simulation and mathematical modeling will yield a better study outcome in the dynamics of paddling inclusive of paddle, seat and footrest forces as a whole (Begon et al., 2010) for a meaningful propulsive force production.

DEVELOPMENT OF ON-WATER MEASUREMENT INSTRUMENTATION

Kinematic data during on-water paddling can be obtained easily either using computer video motion analysis software or combined usage with the available devices on market such as minimaxX unit, PadLog or Digitrainer accelerometer to name the few. However, measurement of the on-water kinetic data is a challenging task and technically difficult. Therefore, the development of instrumentation for on-water measurement in kayaking focus more on the paddle force sensor tools as this is the most crucial data required during on-water paddling. In designing the on-water instrumentation, some general requirements need to be met in developing a useful yet robust acquisition system. Few studies have provided some of the guidelines: (1) waterproof system; (2) lightweight paddle system with less than 3% of the normal kayaker and kayak combined weight or approximately 2-3kg; (3) portable system for usage in different categories of kayak; (4) stable force transducer in the changing temperature and humidity conditions; (5) maintain the paddle length, weight, balance, blade surface and pitch; (6) no alteration in kayaker normal paddling technique; (7) high capacity of signal collection and data recording for at least 5 minutes; (8) high reliability of repetitive analysis with exact real time data presentation; and, (9) ability of the system to simultaneously obtain record of up to four kayakers at one time for multiple kayakers events (Aitken & Neal, 1992; Stothart et al., 1986b).

Similarity is found on the instrumentation of paddle to measure stroke force especially of the aluminum foil strain gauge attached onto the paddle shaft at each end of the paddle shaft near the blade with variation in the distance of the attachment (Aitken & Neal, 1992; Gomes et al., 2011; Stothart et al., 1986b). The first prototype designed by Stothart et al. (1986b) had the cables strapped onto the paddle shaft surface which they then improved by embedding the cables inside the carbon fiber tube which is also applied by Aitken and Neal (1992). Such setting will minimize distraction to the kayakers when paddling during data collection process. When wired system was in use, the amplifier and recording instrument system were all on board the kayak itself where overweight issue arose (Stothart et al., 1986b). Stothart et al. (1986b) then upgraded the system to a FM radio transmitter and decoded data can be stored in data storage rather than on cassette tape in the earlier system. A software named Kayak Data Analysis System (KDAS) is developed by Aitken and Neal (1992) which contained two modules that functioned as a controlling agent of the analog-to-digital conversion board and to provide a graphical display to the user. Both instrumentation developed by Aitken and Neal (1992), and Stothart et al. (1986b) had limitation with the usage of FM transmitter where frequency interference occurred from time to time and range limitation of receiving signal especially for 1000m event. As such, on-water instrumentation is further developed and improved through telemetry system.

Gomes et al. (2011) introduced Paddle system with the implementation of wireless system and they also found that more detailed data of the paddle forces on the shaft is obtained when they used a different setting of attaching the strain gauges on two different planes of the shaft. The latest on-water wireless system instrumentation can be found in the study done by Sturm et al. (2013) of which the data is transmitted onto an Android phone. Their force measurement system comprised of two sensor nodes where the strain gauge is attached to a stainless steel cantilever that can be clamped onto kayak paddle shaft easily and also included in the sensor node a three-axial accelerometer, and a combination of a two-axial and a one-axial gyroscope to detect the inertial motion on the paddle. There is a concern on the accuracy of the force data obtained especially with the various position of the attachment of sensor on the shaft may provide different result. Further study is needed to investigate if force data will vary when there is a variation of grip distance of each kayaker which may affect the positioning of the sensor and also of the various shaft stiffness creating different amount of bending effect (Sturm et al., 2013).

CONCLUSIONS

Future study can be widen onto some of the variables that still require data for comparison as mentioned throughout the review of the present paper which include the effect of using swivel seat in enhancing the paddling performance in the setting of real situation (on-water kayaking). More research in sprint kayaking event in biomechanical study is required especially in validating the motion of paddling in simulation setting using kayak ergometer in the laboratory to replicate the same motion of paddling during outdoor kayaking. There is still a lack of supporting study to validate the effectiveness of simulator usage in transferring the technique effectiveness from on-water kayaking performance. Both the instrumentation in laboratory simulation and on-water performance measurement tools can be further improved to provide a more meaningful analysis. In conjunction with a better design of instrumentation and motion analysis software available, study of joint power and moment is possible and with the combination of data from other high significance variables for achieving greater kayak velocity will provide a whole complete picture of the effective dynamics of paddling in terms of biomechanics study. When a measurement tool has high validity and reliability, the process of learning also will become more effective as the coaches will be equipped with a complete performance analysis during the feedback session with their kayakers.

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MAINTAINING WOMEN'S INTEGRITY DURING CHILDBIRTH THROUGH PARTICIPATORY ACTION RESEARCH

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ABSTRACT

Pelvic floor trauma following childbirth has negative effects on women physically and physiologically. The aim of the study is to improve midwifery practice, so as to optimise birth outcomes and minimise pelvic floor trauma for birthing women. Participatory action research was undertaken at Kuala Lumpur Maternity Hospital by the means of semi-structured interview (senior midwife and obstetrician doctors), focus groups (nurse manager and clinical nurse midwife), direct observation and reflective journals. Data were then analysed using content analysis, thematic analysis and reflection. At the same time, strengthening the qualitative outcomes, a self-administered questionnaire was distributed to nurse-midwife and analysed using the SPSS. The finding revealed that there are several strategies can reduce the rates of pelvic floor trauma: better staff training on evidence-based practiced, the development and implementation new clinical guidelines for midwifery practice in labour ward, coupled with strong internal support. Extensive staff training was planned, and new midwifery practice guidelines were drafted by the researchers in consultation with senior midwives. Change to midwifery practice in labour ward is possible if there is support from key players in the organisations, staff training is extensive and nurse-midwives are supported by evidence-based guidelines.

***Keywords**: Pelvic floor / perineal /pelvic floor trauma, childbirth, risk factors*

INTRODUCTION

Pelvic floor trauma is an all too common outcome of injury to the soft tissues and pelvic floor muscles during the process of vaginal birth (Albers & Borders, 2007; Kettle & Tohill, 2008; Dahlen & Homer, 2008; Kemp, Kingswood, Kibuka, & Thornton, 2013). In Australia, 65.7% of women have some form of pelvic floor trauma, 17.2% of that number is caused by an episiotomy (Laws, Li, & Sullivan, 2010). Even when episiotomy is restricted, 55% to 77% of women still sustained trauma which required suturing (Carrolli & Mignini, 2009). The rates of pelvic floor trauma in Asian countries are similar to that in other developing countries (Ho et al., 2010; Lumbiganon et al., 2010). Traumatic vaginal delivery is associated with soft tissue, nerve and pelvic floor muscle damage. The complication is a significant with long term perineal pain, anal and urinary incontinence and dyspareunia (Albers, Sedler, Bedrick, Teaf, & Peralta, 2005; Steen, 2010). The pain experienced from the pelvic floor trauma interferes with women's ability to take care of and breastfeed their babies, perform routine activities and engage in sexual relations (Kettle & Tohill, 2008; Liebling et al., 2004). Pelvic floor trauma, therefore, may lead to disabling physical, psychological and social problems

and affect the women quality of life (Liebling et al., 2004; Mahony et al., 2007; MacArthur et al., 2011).

Most women have some degree of pelvic floor trauma and consider it a normal consequence of childbirth (Walsh, Green, & Shields, 2007; Walsh & Gutteridge, 2011). Many women suffer in silence from these complications for their entire lives. The ways in which nurse-midwives can assist women to optimise their psychophysiology for childbearing, including the promotion of pelvic floor integrity are known, but not widely implemented (Walsh, 2012). A nurse-midwife can play a major role in teaching and educating childbearing women about strategies which have the potential to minimise pelvic floor trauma during the second stage of labour. The evidence-based practice include position changes in labour; pushing techniques, creating an optimal birth environment, e.g. dimming the lights, temperature control, privacy; providing information about the process of second stage and instructions on antenatal perineal massage (Fahy, Hastie, & Foureur, 2008; Prins, Boxem, Lucas, & Hutton, 2011; Walsh, 2012). Birth Territory Theory provides a framework to understand the way that women's emotions and physiological responses to their birth environment together with issues of power and control within that birth environment affect physiology and behaviour (Fahy et al., 2008).

METHODOLOGY

The research question: How can midwifery practice be improved to optimise pelvic floor outcomes for birthing women? Is most suited to a participatory action research approach because the focus is on engaging nurse-midwives to change their practice in labour ward. This study was designed to inspire Malaysian nurse-midwives to embrace evidence based practice and optimise pelvic floor tract outcomes for birthing women.

Research Design

This study was adopted Participatory Action Research (PAR) because of the potential role to play in the improvement of health care practices and services (Kemmis & McTaggart, 2011; McCormack, 2010; Waterman, Tillen, Dickson, & de Koning, 2001). The purpose of PAR is to improve participant's practical knowledge and their real world situation so that the social environment, within which people interact, can become more harmonious and productive (McNiff, 2013; Reason & Bradbury, 2008). Practice development research supports nurses, midwives and health team to critically reflect on their practice and identify how it can be improved. In healthcare, the combination of PAR and practice development approach was described as a method for developing and changing clinical practice (McCormack, 2010; NSW Health, 2008). Figure 1 showed the two cycles of PAR were used in this study. However, in this paper the focus is PAR Cycle 1 only.

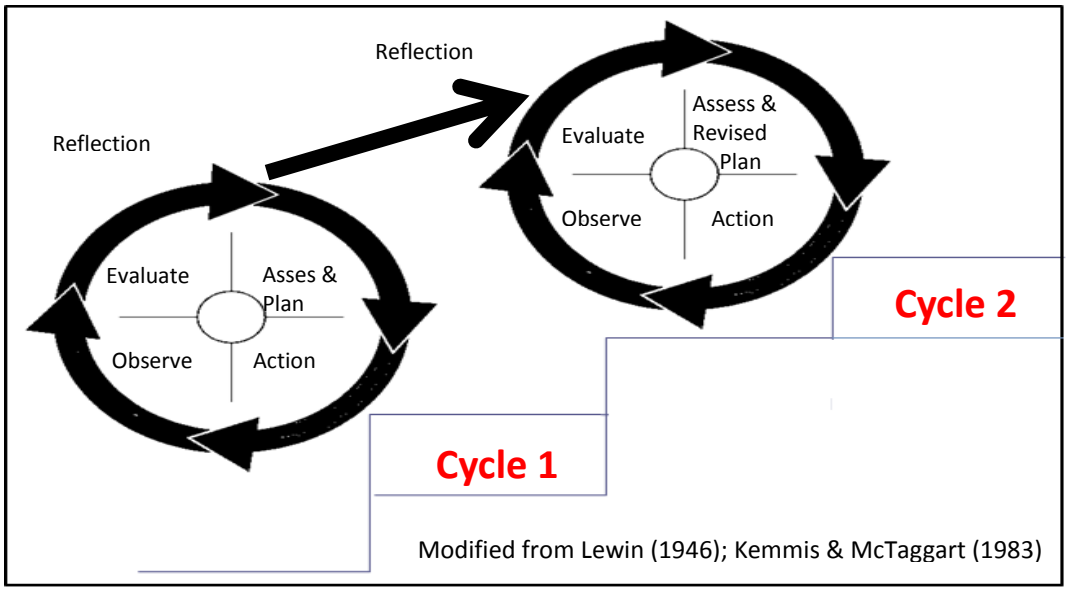

Figure 1. Participatory action research cycles.

Activities in Participatory Action Research Cycle 1

An outline of the Participatory Action Research Cycle one is presented in Figure 2 below. The process of Participatory Action Research is divided into phase 1 (Assess and Plan), phase 2 (Act and Observe) and phase 3 (Reflect and Evaluate).

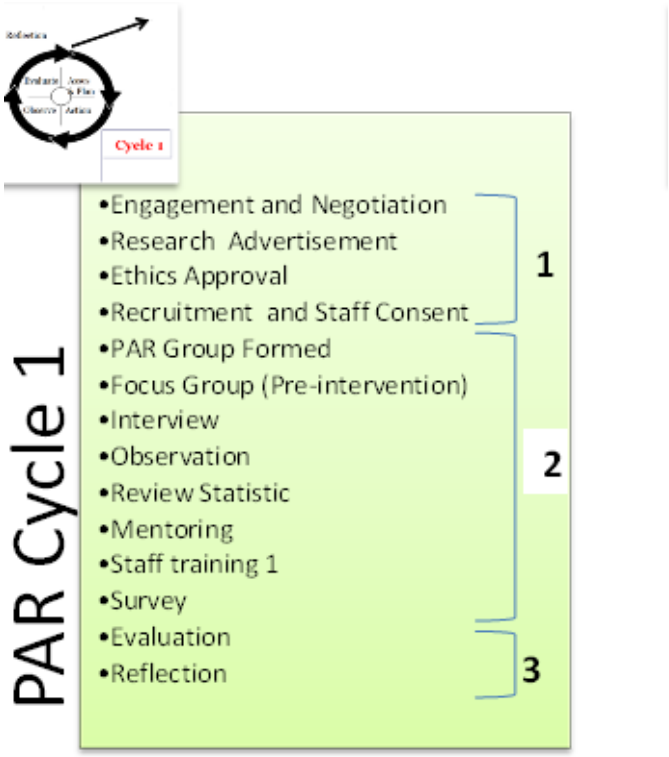

Figure 2. The Participatory action research Cycle 1.

Methods of Data Collection and Analysis

Consistent with the methodological principle of triangulation, six methods of data collection were used in this study. These methods of data collection are: 1) Individual interviews with senior staff, 2) focus groups with nurse-midwives, 3) Direct observation in labour ward, 4) Learning needs surveys, and 5) Personal reflective journal.

RESULTS

The findings from PAR Cycle 1 were identified and explored in this paper. All the baseline information that has been gathered in PAR Cycle 1 was analysed. The content analysis and thematic analysis were used to analyse the qualitative research data. Descriptive analysis of the survey was analysed by SPSS Version 19. Personal reflection and direct observations were concurrently used throughout the study.

Focus Group Pre-Intervention

Two focus group interviews were held in order to inform the current practice and knowledge related to pelvic floor integrity. The results showed in Table 1 below.

Table 1. Content analysis for focus group

Categories	Broader Category	Frequency
Thick perineum Nulliparous woman Baby too big i.e. 4 Kg or more	Anatomical Abnormality	12
Language barrier prevent women's cooperation Women Lifts the buttock against expectation/advice Precipitate labour	Lack of coordination of birthing between woman and clinician	9
Lack of clinician skill Clinician did not guard the perineum	Unskilled clinician did not guard the perineum	6
Categories	**Broader Category**	**Frequency**
Lubricate the perineum during second stage Guard the perineum Improve Staff knowledge Improve Staff skill Perform perineal massage during second stage Episiotomy	Improve staff knowledge/skills	29
Ensure maternal Cooperation Antenatal education	Prepare women for birth and to follow instruction	18
Professional collaboration	Collaboration	2

The finding from the focus groups demonstrated that nurse/midwives believe the causes of preventable perineal trauma lie almost entirely in the faulty anatomy of women and/or their babies or with the woman failing to follow the midwife's 'instructions'. Where the participants said that the clinician contributed to perineal trauma it was because they could not gain the cooperation of the woman or they were not guarding the perineum during the birth of the head. All of these beliefs, with the exception of woman/midwife collaboration, have no evidence base and are therefore false beliefs.

Individual Interviews

Nurse Managers and senior clinician were interviewed about their perspective on the report and possible way to forward in improving practice personal reflection. There were two main questions in the interview session and results as shown in Table 2.

Table 2. Content analysis for interview.

Question 1: What does senior staff believe is preventing clinicians from doing more to prevent genital tarct trauma?	
Categories	Frequency
Busy medicalised environment (staff rushing and busy, need to speed up birth, rely on doctors' orders, lack of stable staff, students needing to practice)	10
Resistance to change (including not our culture/staff attitudes/recumbent position is normal)	7

Question 2: What do senior staff believe would need to change in order to reduce genital tarct trauma rates?	
Categories	Frequency
Improve staff education and supervision	7
Antenatal perineal massage (with oil)	4
Upgrade facility	2
Improve woman's education about birthing	2
Perineal massage/lubricant in labour	2
Implement evidence-based practice re episiotomy rates	1

The findings from individual interviews with the senior managers and directors of obstetrics and nursing showed that they shared many of the false beliefs of the nurse/midwives in the focus groups. The senior staff believe that pelvic floor trauma rates could be reduced with i) better staff training and supervision, ii) the implementation of evidence-based practice and iii) an upgrade to the labour ward. They believe that the reason perineal trauma rates as so high is that many staff are resistant to change and do not understand or value research. They agreed that midwives need to learn about evidence based practice. These senior staff believe that making any change in labour ward practice will be very difficult because it is highly medicalised, very busy with high nursing and medical student turnover.

Learning Needs Survey

Informed from the literature review and the results of the individual interviews, I designed a learning needs survey for labour room staff. The survey was reviewed by members of the PAR group to ensure that it was appropriate for the staff we intended to survey. A total of 68 registered nurse/midwifery staff (out of 110 staff members) participants completed and returned the survey for a response rate of 61%. The majority respondent age is between 31-40 years with only 6 respondents aged over 50. The overall results of the survey can be seen in Table 3.

Table 3. Summary of findings from the learning needs survey.

Statement	**Total answered**	Strongly disagree	Disagree	Agree	Strongly agree	**Total agree**	**Total Disagree**
The environment of the room has NO effect on the woman's labour	**85**	20 23.5%	34 40%	26 30.5%	5 6%	**31** 36.5%	**54** 63.5%
The policy of the maternity unit should **REQUIRE** midwives to:							
Make ALL women wear hospital clothes	**87**	5 5.7%	2 2.3%	53 61%	27 31%	**80** 91.9%	**7** 8.1%
Keep ALL women lying on the bed throughout labour	**87**	4 4.6%	33 38%	41 47.1%	9 10.3%	**50** 57.5%	**37** 42.5%
Prevent ALL women from drinking clear fluids as desired in labour	**86**	13 15.1%	34 39.5%	35 40.7%	4 4.7%	**39** 45.3%	**47** 54.7%
Encourage ALL women to birth (deliver) in supine position	**87**	13 15%	32 36.8%	37 42.5%	5 5.7%	**42** 48.3%	**45** 51.7%
Maintain continuous CTG on ALL women, even if normal	**86**	12 14%	27 31.4%	39 45.3%	8 9.3%	**47** 54.7%	**39** 45.3%
Direct ALL women how and when to push in labour	**87**	3 3.5%	5 5.7%	40 46%	39 44.8%	**79** 90.8%	**8** 9.2%
Cut an episiotomy to prevent perineal tearing	**87**	4 4.6%	16 18.4%	54 62%	13 15%	**67** 77%	**20** 23%

These findings from the ***learning needs survey*** demonstrate that the majority of the respondents did not know or support evidence-based practice to reduce perineal trauma: e.g. most agreed that midwives should require women to to: i) make all women wear hospital clothes; ii) direct all women how and when to push; and, iii) cut an episiotomy to prevent perineal tearing. The learning needs survey indicates both a lack of knowledge of evidence-based practice and a lack of knowledge about active birthing practices that can minimise perineal trauma. These two major topics formed the foundation of the educational strategy which became the intervention in this study.

DISCUSSION

Many women and nurse-midwives passively accept the incidence of pelvic floor trauma as an inevitable and normal consequence of childbearing (Thompson, Roberts, Currie, & Ellwood, 2002; Walsh, 2012). Nurse-midwives have a professional responsibility and duty of care to preserve pelvic floor integrity or at least minimise the injury (Albers et al., 2005; Walsh, 2012). As the data found that most of the nurse-midwives were lack of evidence-based practice, a serial of the education session was developed. Therefore, midwives are required to base their professional practice on current research findings and relevant evidence in delivering care for women. The evidence is clear that trauma to the pelvic floor or pelvic floor can often lead to long term complications (Herbruck, 2008; Samarasekera, Bekhit, Preston, & Speakman, 2009; Revicky & Nirmal, 2010). The PAR group was established and actively engaged in the research project and were involved in education and staff training. The PAR group consisted of nurse managers and they played a major role in changing practice as they could instruct nurse-midwives to slowly change their practice on research evidence.

CONCLUSION

PAR Cycle 1 was conducted during the first six months on this project according to the process of an action research cycle. The data that has been gathered in PAR Cycle 1 revealed that majority nurse-midwives practice not on evidence based and lacked of research and evidence based practice knowledge. The focus for midwifery practice to change, therefore, should be by educating and emphasizing evidence based practice. This is because the factors that are related to the risk of pelvic floor trauma can be modified by implementing evidence- based midwifery practice through research findings from high ranking clinical evidence. The process of PAR cycle 1 is one of the strategies to gradually increase their awareness and knowledge based on research evidence. The findings from PAR cycle 1 were used to develop a new strategy to improve staff knowledge and skills, and the development of practice guideline in PAR Cycle 2 was discussed and planned with the PAR Group.

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DEVELOPMENT OF ARTIFICIAL NEURAL NETWORK MODEL IN PREDICTING PERFORMANCE OF THE SMART WIND TURBINE BLADE

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ABSTRACT

This paper demonstrates the applicability of Artificial Neural Networks (ANNs) that use Multiple Back-Propagation networks (MBP) and Non-linear Autoregressive with Exogenous (NARX) for predicting the deflection of the smart wind turbine blade specimen. A neural network model has been developed to perform the deflection with respect to a number of wires required as the output parameter. The parameter includes load, current, time taken and deflection as input parameters. The network has been trained with experimental data obtained from experimental work. The various stages involved in the development of genetic algorithm based neural network model are addressed at length in this paper.

Keywords: Artificial neural network; back-propagation; multiple back-propagation; non-linear autoregressive with exogenous.

INTRODUCTION

Glass fibre reinforced polymer (GFRP) is a promising material for renewable energy which has been mainly used in the wind turbine blade. The choice is due to high and strength weight ratio (Nolet 2011). The application of GFRP laminates improves the ultimate strength in capturing wind as proportional diameter of the blade (Sorensen et al. 2004). However, a longer blade will result in deflection since the bending moment is high from the tip to root. At this point there is more blade outboard (contributing to bending moment) than at any other point along the blade (Peter & Richard 2012). At the tip the bending moment drops to zero as shown in Figure 1. The nature of the composite material is a high non-linear system. It is very crucial problem to describe the characteristics of composite load deflection. To alleviate the deflection of the GFRP, it will be enhanced to use Shape Memory Alloy (SMA) wires (Supeni et al. 2012a; Supeni et al. 2012b). As the Artificial Neutral Network (ANN) has a strong ability of describing non-linear mapping, there are many uses in load modelling studies, and researchers have been trying to describe the complex characteristics of the performance of the composite load precisely (Sapuan & Iqbal 2010). The neural network is used in the parameter identification of traditional such as difference equations model, power function model and polynomial function model, but the BP neural network is only used as an optimization algorithm, and the structure of the models have not improved; disadvantage such as slow convergence and local minimum (Gayan et al. 2013). The performance of GFRP plated specimens depends on the load applied, internal structure of SMA and current applied. This paper presents the results of experimental

investigations carried out on 6 SMA wires reinforcing a rectangular plate along with an Artificial Neural Network (ANN) based model for performance prediction.

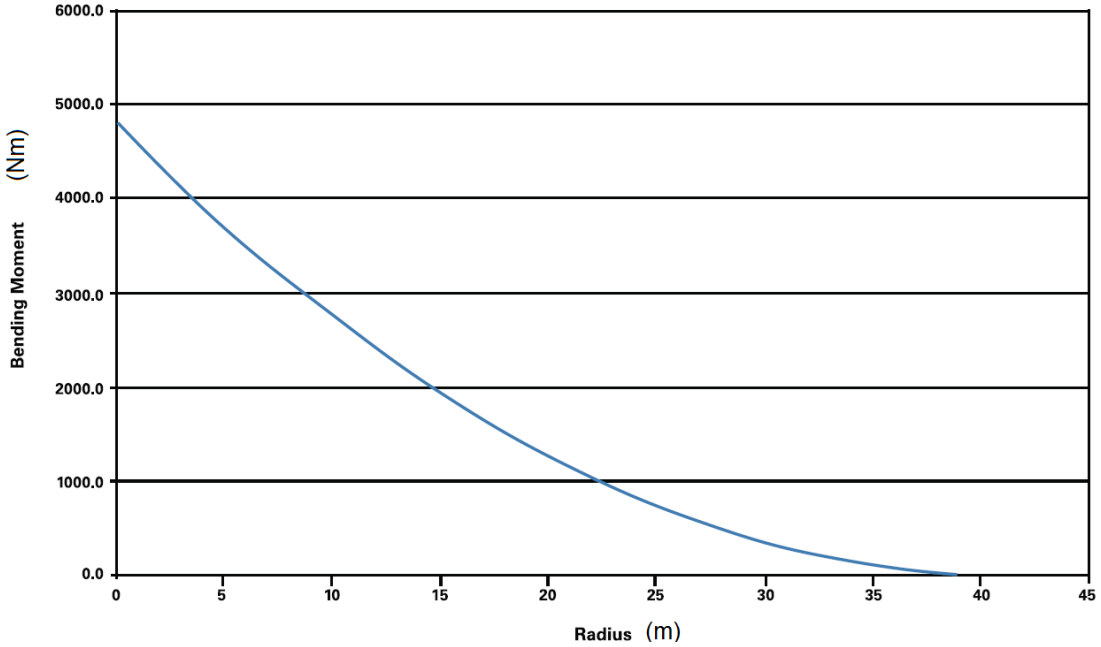

Figure 1. Bending moment against radius in a large turbine blade (Nolet 2011).

RESEARCH SIGNIFICANCE

The effect of current applied of SMA wires and correlation of the deflection of the plate has been modelled in ABAQUS in Figure 2 and tested experimentally in Figure 3 (ABAQUS 2012). The results obtained from the investigation were used to generate an ANN based design tool for predicting the amount of wire needed to restore the original shape of such bending. This depends on parameters such as deflection, the total current and the applied load.

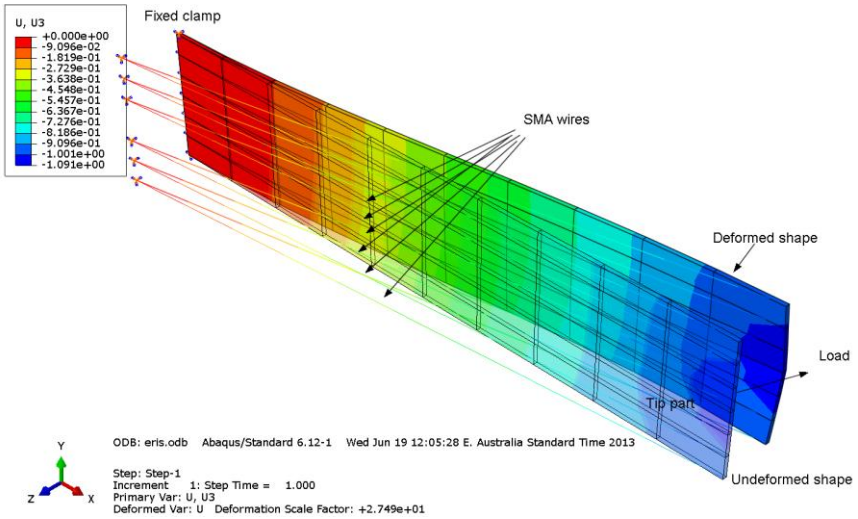

Figure 2. The plate simulated in ABAQUS FEA.

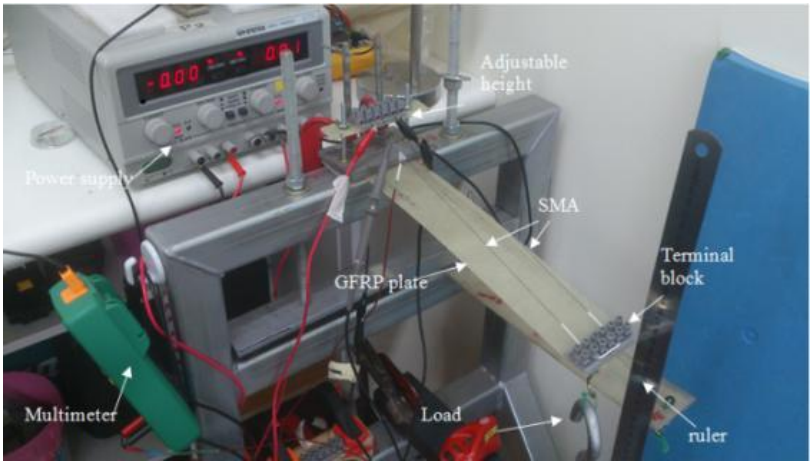

Figure 3.Photograph of tested composite plate.

METHODOLOGY

This study is to evaluate the predictive ability using Machine Learning (ML) which is MBP and NARX. The performance comparison between Multiple Back-Propagation (MBP) and Non-linear Autoregressive with Exogenous (NARX) are undertaken. To facilitate the performance comparison, all networks simulated have been designed and trained accordingly from output layers, hidden layers and output layers. Output neurons use hyperbolic tangent activation functions. The standard back-propagation algorithm is used to train the networks with learning rate equal to 0.01. Once a given network has been trained, it is required to provide estimates of the future sample values of a given time series for a certain prediction. The predictions are executed in a recursive curve until desired prediction horizon is reached, i.e., during N time steps the predicted values are fed back in order to take part in the composition of the regressors. The networks are evaluated in terms of the root mean square error (RMSE). The parameter such as applied load (L), applied current (I) and deflection (d) have been used as input and number of wire (NW) as the output to designed ANN. The general schematic diagram is illustrated in Figure 4.

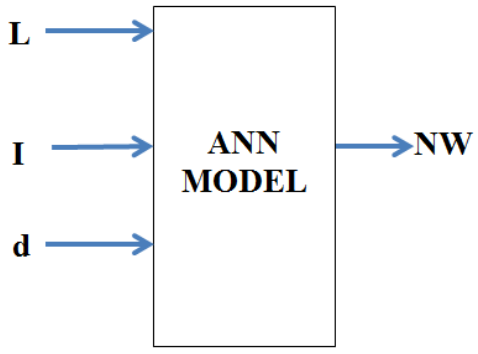

Figure 4. General structure of model ANN.

The network structure of the proposed ANN was divided into three randomly selected batches. The batches comprised of the training batch, testing batch and validation batch. The regression analysis capacity of the network could be checked after training phase. The mean square error (MSE), determination coefficient R and root

mean square errors (RMSE) were measured by the suggested neural network. In total, 162 data sets were selected for the design of ANN which were broken down into each target time steps which were 130, 16 and 16 for training, testing and validation respectively.

MBP Method

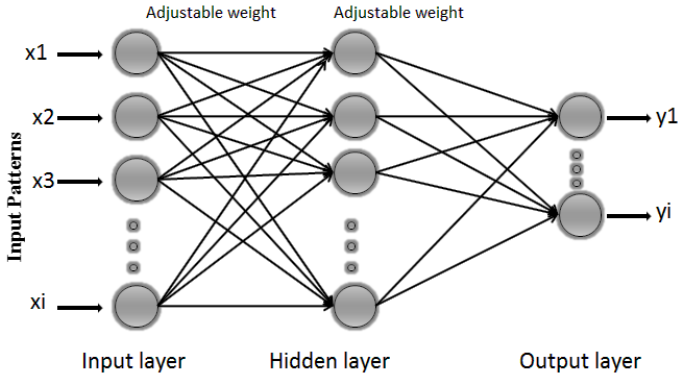

Figure 5. Diagram of MBP network.

Figure 5 illustrates a learning process of multi-layer neural network employing back propagation algorithm. To illustrate this process the three layers neural network, for example, three inputs, three hidden layers and one output were implemented. Two types of sigmoid activation functions were selected for several numbers of hidden, output layer 2 which are logarithmic sigmoid function (logsig) and hyperbolic tangent sigmoid function (tansig) respectively. The adjustable weights used to propagate errors back were equal to the one used during computing output value. Only the direction of data flow was changed (signals are propagated from output to inputs one after the other). This technique was used for all network layers. For comparative study, a free opened source software has been used to generate the MBP which use program code C (Noel & Bernardete 2001; Noel & Bernardete 2003) .

NARX Method

NARX which is depicted in Figure 6, has been used to predict values of a time series, y(t), from past values of that time series and past values of a second time series, x(t). In this experiment, NARX consists of numbers of hidden layers, numbers of delay lines (D) and one output neuron with two layer feed forward networks were used in these experiments. The standard Lavenberg-Marquardt (LM) back propagation algorithm is used to train the network with learning rate close to 0.001. The method of regularization has been used which consist of 1000 epoch and the regularization parameter used is 1.00e-05. MATLAB code has been used to run the ANN toolbox (nntool) that has been generated by using the mode LM back-propagation (trainlm)(Howard & Mark 2000).

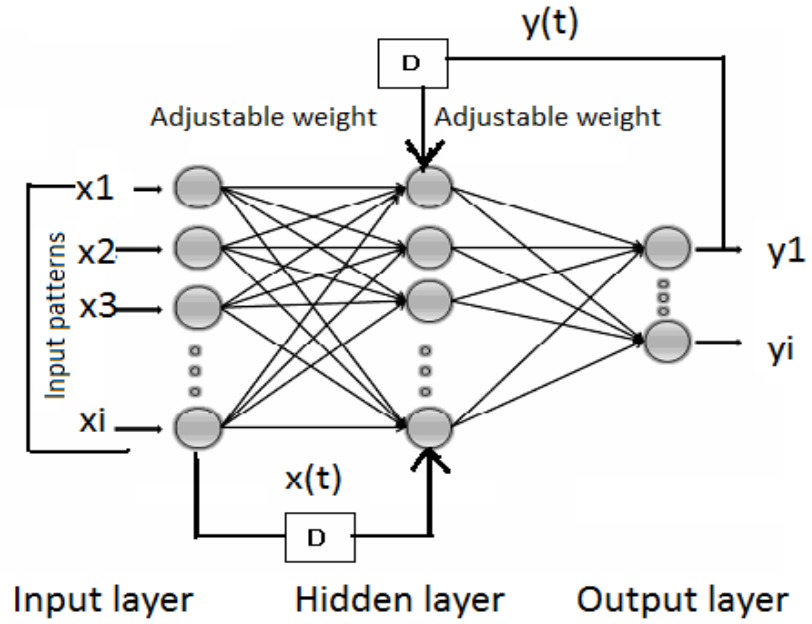

Figure 6. Diagram of NARX network.

RESULTS AND DISCUSSION

The number of SMA wires applied has been considered as an output vector. Applied current, deflection and load are considered as the input vectors. All calculations of neural network were made using MATLAB (Levenberg-Marquardt) and MBP open source code. The schematic diagrams of the both models are displayed in Figure 7 and 8. Both LM and MBP algorithms for training were applied to the network. The application randomly divides input vectors and target vectors into three sets, as follows. 80% are used for training. 10% are used to validate that the network is generalising and to stop training before over-fitting. The last 10% are used as a completely independent test of network generalisation. Data from experiments were collected to train the performance deflection number of wire with response to the load applied, deflection and the current applied. About 162 values of data were used for these networks. Table 1 shows NARX1 model with the lowest MSE among other model of ANNs and the fastest mode convergence training network. As can be seen from Table 2, the smallest values of MSE and the high values of R give us reason to consider the obtained NARX models as adequate which are almost to unity.

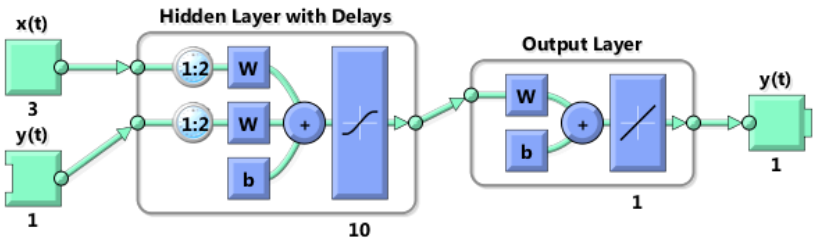

Figure 7. Example of NARX network with 10 hidden layers and 2 delays time by MATLAB.

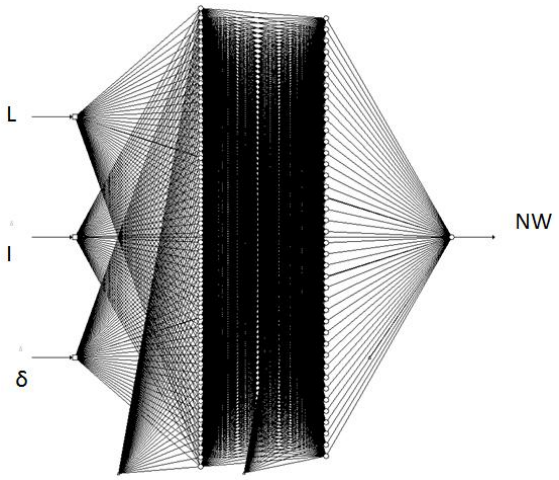

Figure 8. Example of MBP diagram network with 50-40 hidden layers.

Table 1.Predicting the deflection with respect to number of wires using various model.

Model	Input vector	Output vector	Structure/No hidden layer neuron	Epoch (No. of Iteration)	Mean Square Error (MSE)
MBP1	L,I,d	NW	50-40	1,273,277	0.009999
MBP2	L,I,d	NW	50-40-30-20	437,788	0.009997
NARX1	L,I,d	NW	10 delay time 2	26	0.000308
NARX2	L,I,d	NW	10 delay time 3	10	0.001542
NARX3	L,I,d	NW	10 delay time 4	7	0.002337

Table 2. The detail results of the NARX model training for NARX.

	Target value	MSE	R
Training	130	8.12988E-5	9.99145e-1
Validation	16	3.08830E-4	9.99289e-1
Testing	16	3.49000E-3	9.99597e-1

The best validation performance is provided in Figure 9. It shows that the process of the network's performance has improved during training. This performance is measured in terms of MSE and it is shown in log scale. It is evident that the MSE has decreased rapidly along epochs while the network is trained. In this case, the results are reasonable considering the final mean-square error is very small which are the test set error and the validations set error that have similar characteristics. In Figure 10, the training, test and validation data indicate good curve fitness. The validation and test results also show that the overall values is greater than 0.9. Figure 11 shows how the error sizes are slightly well distributed. Typically, when most errors are near zero, it has been observed a better trained model. In this case however, it is confirmed that the network also have errors near zero.

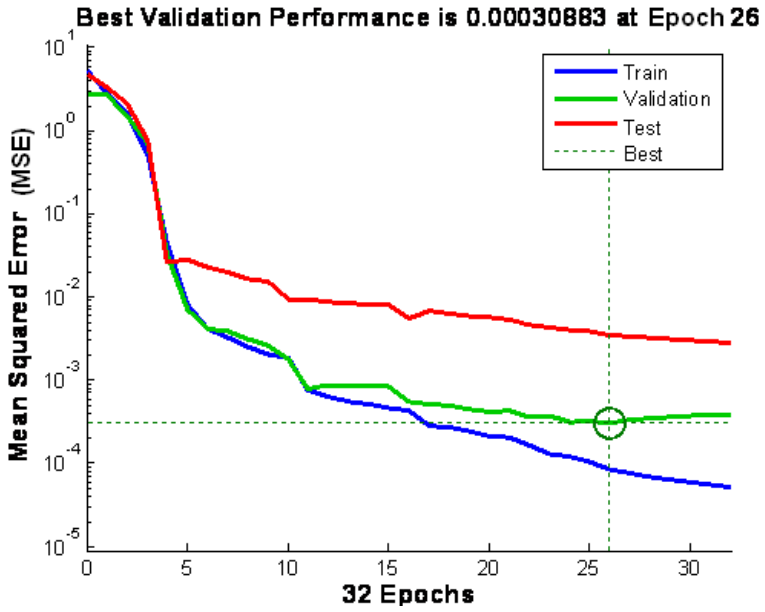

Figure 9. The network's performance.

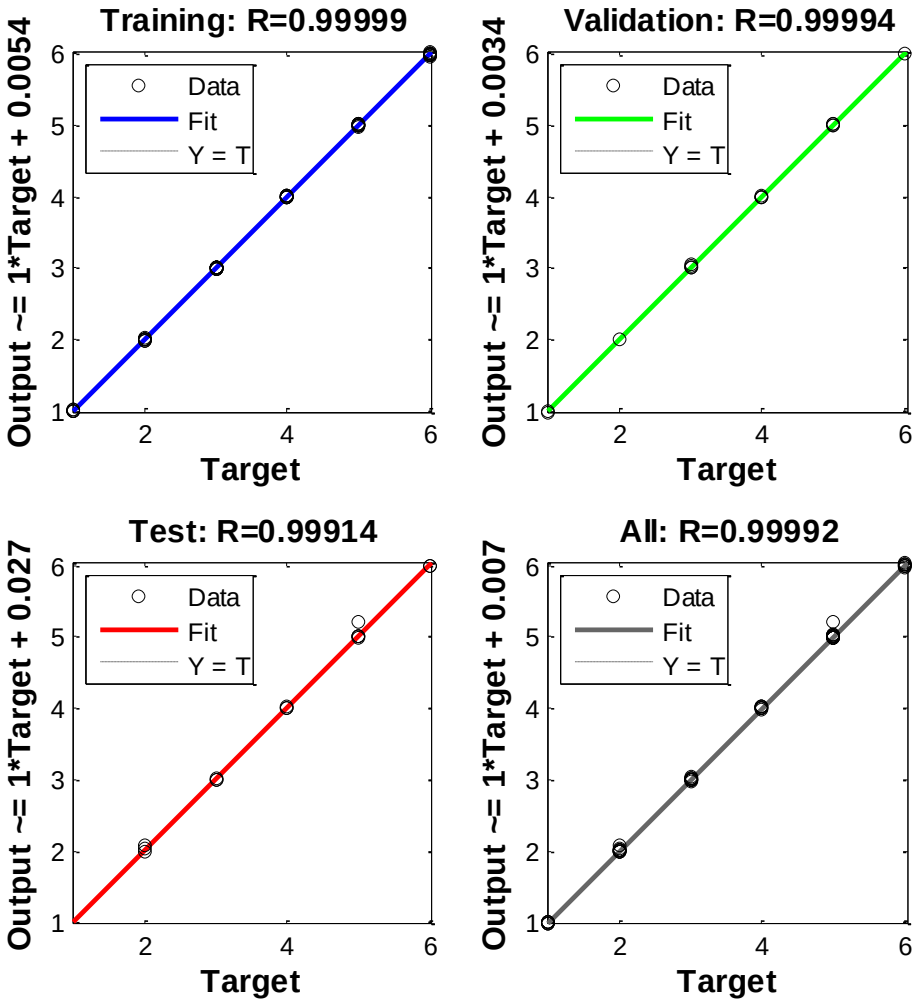

Figure 10. Regression analysis plot for the NARX .

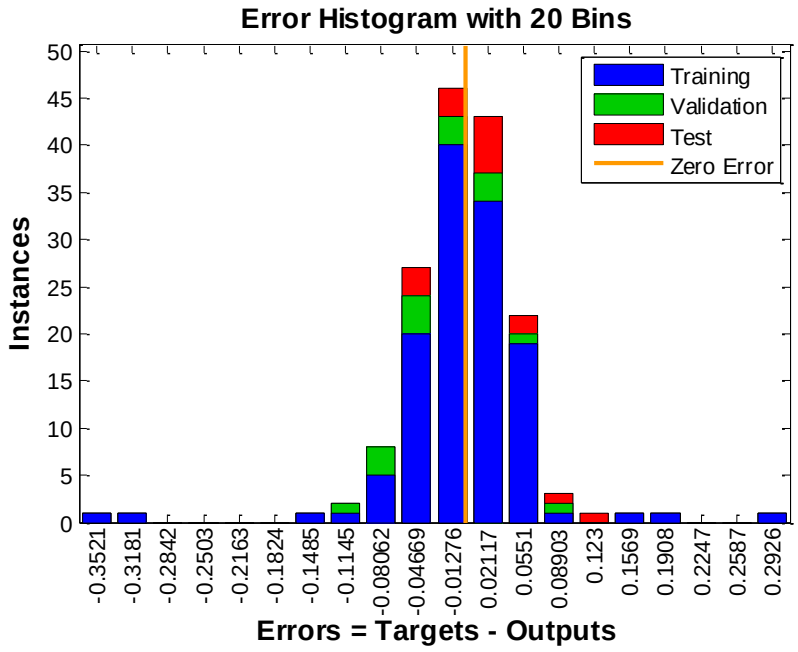

Figure 11. Error histogram of the NARX prediction model

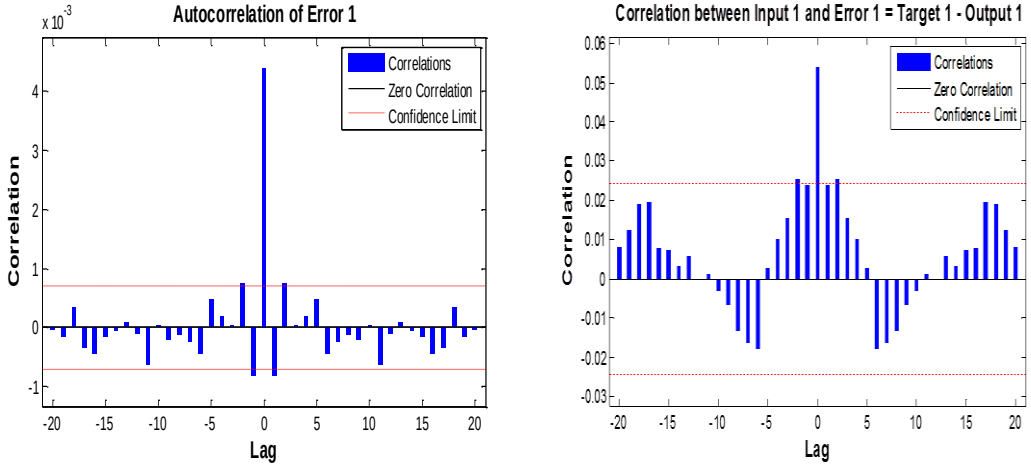

Figure 12. Auto-correlation of errors of NARX prediction model and correlation between input and output with respect to target function.

The correlation between input and error is provided in Figure 12. This figure illustrates how the errors are correlated with the input sequence. The perfect prediction model means that all the correlations should be zero. In this case, all of the correlations are within the confidence bounds around zero. The function of auto-correlations of errors is used to validate the network performance. Auto-correlation describes how the prediction errors are related in time. For the perfect model, there should be only one non-zero value of the auto-correlation at zero lag. This means that there is no correlation in prediction errors with each other. In this case, the correlations, except the one at zero lag, are within the 95% confidence limits. Based on the various diagnostics described up to now, it can be concluded that the model is adequate. Figure 13 confirms that the responses, obtained from the NARX prediction model for the performance deflection,

are adequate, since the errors are quite small. For comparison, similar shape also has been obtained as shown in Figure 14. The predictions obtained based on both methods of network training, the NARX has improved the training network compared to the MBP networks. In MBP, there are still network output errors with respect to desired output network. Although the errors are not correlated with the input sequence, all the correlations are not within the 95% confidence limit.

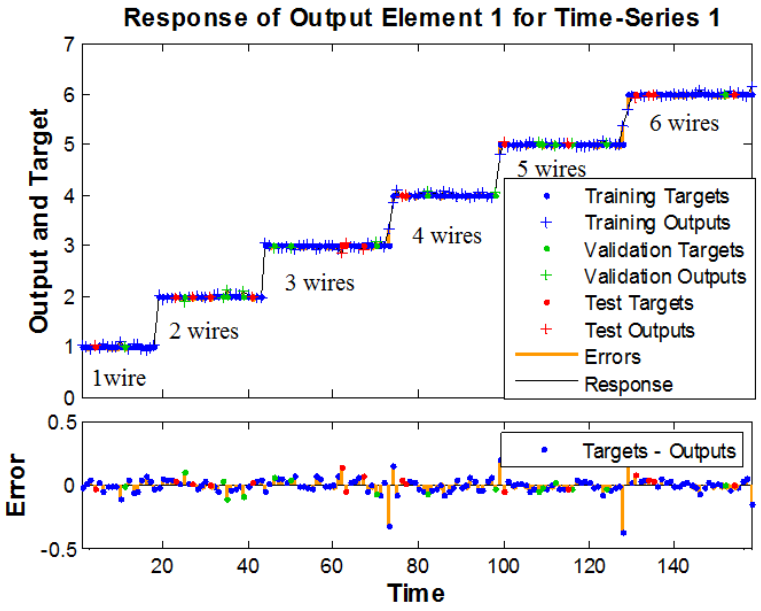

Figure 13.Response of NARX prediction model for performance deflection (trained by the Levenberg- Marquardt algorithm)

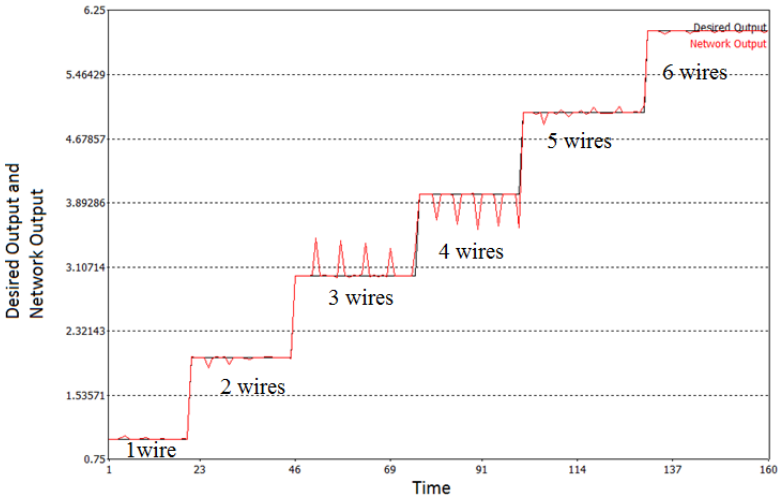

Figure 14. The desired output and network output by MBP by opened source C code

CONCLUDING REMARKS

In this study, the ANN model with different network training methods was applied for predicting the amount of wire needed to restore the original shape that recover from deflection. The NARX and MBP algorithm for training of the network were used. The first conclusion of the paper is that although neural models may frequently suffer from a certain degree of inaccuracy, the results show that the NARX model applied to the

deflection of SMA has proven the productivity and relation quality, while using less of computational expenses. The NARX model was chosen since it resulted in the best performance, according to MSE. Therefore, the NARX models have the potential to capture the dynamics of non-linear systems. The second conclusion is that the NARX models are mainly dependent on the applied architecture and training method. Within the context of architecture, the behaviour of NARX models mostly depends on the numbers of neurons in hidden layers. Too many hidden neurons in network cause over-fitting that, in turn, leads to poor predictions. Future modeling of the NARX is to model ANN 2 and ANN 3 which use deflection and applied current as the output vectors respectively.

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HIGH RISK HABITS IN RELATION TO ORAL CANCER IN TWO SELECTED INDIAN COMMUNITIES IN MALAYSIA AND INDIA: A DESCRIPTIVE STUDY

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ABSTRACT

The study aimed to evaluate the risk habits in relation to oral cancer in two selected Indian communities in Malaysia and India and to examine the reasons for practicing these habits and also accessing their knowledge and perception about the risk of oral cancer. A cross-sectional household survey was carried out based on a structured questionnaire (pre-tested) employing the face to face interview technique as well as observation. The interview was undertaken by two examiners by means of house to house survey. A total of 84 subjects from Ipoh, Malaysia and 103 from Dharwad, India completed the questionnaire. All the subjects had one or more risk habit at the time of the study. More than half (57.1%) of the respondents among the Ipoh group were current smokers whereas just over one third (33.0%) were smokers among the Dharwad group. Half of the respondents (n=42) were current alcohol users among the Ipoh group whereas one fifth (20.4%) had the habit among the Dharwad group. Slightly more than two third (29/84) of the Ipoh respondents had betel quid chewing habit. However, the habit was more common among the Dharwad group (71/103). In Ipoh group, more than half (54.8%) of the respondents had knowledge on oral cancer. However, the percentage was even less among the Dharwad group as only 44.9% had known about oral cancer. Similar patterns were observed about the perception of oral cancer among the two groups as only 15.5% and 11.7% of the respondents among the Ipoh and Dharwad group respectively felt that they are susceptible to oral cancer. In conclusion, the prevalence of high risk habits in both communities was found to be high despite having some knowledge on oral cancer. Social lifestyle and environmental changes is necessary to eradicate these high risk habits.

***Keywords*:** Oral cancer; smoking; betel quid; prevalence of oral cancer.

INTRODUCTION

Oral cancer is the sixth most common malignancy reported worldwide, and it has one of the highest mortality rates among all cancers. Worldwide, around 275,000 cases of oral cancer are diagnosed yearly and more than 125,000 deaths are attributed to this disease (Parkin at al, 2005). It has been estimated that 1/10,000 adults are diagnosed with oral squamous cell carcinoma (OSCC) in the United States, 1.3/10,000 in the United Kingdom, and 2/10,000 in India. Unfortunately, OSCC is usually recognized when symptoms develop, and approximately two thirds of patients have advanced stage of disease at time of

diagnosis (Epstein at al,1986; Silverman and Gorsky 1990). Overall survival from OSCC has changed little in decades (Parker et al, 1997). Based on global evidence, the most important risk factors for oral cancer are tobacco, excess consumption of alcohol (La et al,1997) and betel quid usage (IARC,2004), these factors act separately or synergistically (Blot et al,1988). The attributable risk of oral cancer due to both tobacco and alcohol is estimated to be more than 80% (Warnakulasuriya, 2009). Heavy drinkers and smokers have 38 times the risk of abstainers rom both products (Blot et al, 2009). All forms of tobacco are carcinogenic and evidence for smokeless tobacco causing oral and pharyngeal cancer have recently been evaluated and confirmed (IARC, 2007).

India has always been cited as the country with the highest incidence in the world, though in some recent reports Sri Lanka and Pakistan are ranked at the top. Malaysia being a multiracial country also has a large number of Indian migrants (7.3%) which contributes to 60% of all reported cases oral cancer in Malaysia (Department of statistics Malaysia,2011). Several studies describe patterns of oral cancer incidence among migrant groups, most of which reflect life style influences. Studies on migrants and minority ethnic populations in Britain have reported significantly higher incidence rates in South Asian populations living in Greater London, Birmingham and Yorkshire (Warnakulasuriya,1999; Bedi,1996).The increasing oral cancer rates in countries to which South Asians have migrated in large numbers, coupled with easy access to tobacco and areca products and difficulties accessing the healthcare system, suggest that a comprehensive approach to oral cancer assessment and prevention in South-Asian immigrants is imperative. The aim of this study was to evaluate the risk habits in relation to oral cancer in two selected Indian communities in Malaysia and India. We also examined the reasons for practicing these habits and also accessed their knowledge and perception about the risk of oral cancer.

MATERIALS AND METHODS

The study was carried out on Indian population aged over 20 years based at two separate location namely Ipoh, Malaysia and Dharwad, India. Recruitment of subjects was voluntary. Ethical approval for the study was obtained from the University of Malaya Ethic.A cross-sectional household survey was carried out based on a structured questionnaire (pre-tested) employing the face to face interview technique as well as observation. All the participants read a sheet outlining details of the study, gave consent, and completed a confidential questionnaire which was translated in Tamil (a language spoken by the selected Indian community). Questions covering age; ethnic origin; religious belief; use of alcohol, tobacco, paan, areca nut and paan masala; reasons for practicing the habits and knowledge of oral cancer risk and prevention were answered by a combination of ticking relevant boxes and filling in blank spaces on the form. Reverse translation was done by a professional translator (Mr. J) in order to ensure the accuracy. In addition to the face to face interview, photographs and videos were recorded (with consent) to observe the manner in which various ingredients are prepared and used. The interview was undertaken by two examiners by means of house to house survey. A total of 84 subjects from Ipoh, Malaysia and 103 from Dharwad, India completed the questionnaire. All the subjects had one or more risk habit at the time of the study. All the forms were verified for completeness. The data was coded before entering into

a computer using the IBM SPSS 11.5 (Statistical Package for Social Sciences. Following the data cleaning, descriptive and analytical statistics were performed.

RESULTS

A total of 187 subjects (Ipoh 84; Dharwad 103) participated in the study. Table1 shows the demographic data for the subjects.

Table 1. Demographic data of the subjects (n=187).

	Ipoh, Malaysia n=84(%)	Dharwad, India n=103(%)
Age group		
20-39	24 (28.5)	37 (35.9)
40-59	35 (41.7)	42 (40.8)
> 60	25 (29.8)	24 (23.3)
Education level		
No formal education	12 (14.3)	41(39.8)
Primary school	32 (38.1)	18(17.5)
Secondary school	39 (46.4)	27(26.2)
College/university	1 (1.2)	17(16.5)
Occupation		
Professional	2 (2.4)	1(1.0)
Intermediate/lower professional	37 (44.0)	25(24.3)
Skilled (manual/non-manual)	1 (1.2)	1(1.0)
Unskilled (manual)	22 (26.2)	48(46.6)
Unemployed	22 (26.2)	28(27.2)
Income (in Ringgits, Malaysia)		
< RM 500	0 (0.0)	45(43.7)
RM 500 – RM 1500	64 (76.2)	37(35.9)
RM 1500 – RM 3500	8 (9.3)	19(18.4)
> RM 3500	12 (14.5)	2(1.9)
Tobacco history		
Smoker	48 (57.1)	34(33.0)
Non-smoker	36 (42.9)	69(70.0)
Alcohol history		
Current user	42 (50.0)	21(20.4)
Non-user	42 (50.0)	82(79.6)

Smoking Status Among the Ipoh and Dharwad Group

More than half (57.1%) of the respondents among the Ipoh group were current smokers whereas just over one third (33.0%) were smokers among the Dharwad group (Table 2). The habit was almost totally confined to males in both the group with only 1 female found to be a smoker in each group. In the Ipoh group, a high proportion of the smokers were among the young adults (20-39 years) whereas majority of the smokers were elderly (40-59 years) among the Dharwad group. In both groups, higher proportion of the respondents was chronic smokers. Commercial cigarettes were found to be more preferred type of smoking (70.8%) among the Ipoh

group whereas Bidi was more commonly practiced in the Dharwad group. In Ipoh group, the primary reason for starting the smoking was to release tension (43.8%) whereas in the Dharwad group majority of the respondents (35.3%) started the habit just for fun.

Table 2. Data of tobacco users

India	Ipoh, Malaysia n=48(%)	Dharwad, n=34 (%)
Gender		
Male	47 (97.9)	33 (97.1)
Female	1 (2.1)	1 (2.9)
Age groups		
20-39	21 (25.0)	9 (8.7)
40-59	18 (21.4)	17 (16.5)
> 60	9 (10.7)	8 (7.8)
Duration (years)		
1 – 3	1 (2.1)	3 (8.8)
4 – 7	4 (8.3)	5 (14.7)
8 – 11	8 (16.7)	3 (8.8)
12 – 15	5 (10.4)	4 (11.8)
> 16	30 (62.5)	19 (55.9)
Frequency (per day)		
1 – 5	2 (4.2)	3 (8.8)
6 – 10	5 (10.4)	10 (29.4)
11 – 15	3 (6.3)	2 (5.9)
16 – 20	23 (47.9)	7 (20.6)
> 21	15 (31.3)	12 (35.3)
Type		
Cigar	8(16.7)	0(0.0)
Bidi	6(12.5)	18(52.9)
Commercial cigarettes	34(70.8)	16(47.1)

Alcohol Status Among the Ipoh and Dharwad Group

Half of the respondents (n=42) were current alcohol users among the Ipoh group whereas one fifth (20.4%) had the habit among the Dharwad group (Table 3). The habit was more common among males in both the groups and was mostly present in the older adults (40-59 years). In both the groups, higher proportion of the respondents were chronic alcohol users as almost three fifth (Ipoh group n=25; Dharwad group n=12) had the alcohol habit for more than 16 years. The maximum glass of alcohol consumed in both the groups was 6. Interestingly, majority (n=13) of the respondents among the Dharwad group were among those who consumed 6 glasses

of alcohol per day. Beer was the most preferred alcohol among the Ipoh group whereas Whiskey was more popular among the Dharwad group. In Ipoh group, alcohol was mainly practiced for socializing (28.6%) whereas in Dharwad group, the reason for indulging into this habit was mainly for fun (33.4%).

Table 3. Data of alcohol users.

	Ipoh, Malaysia n=42 (%)	Dharwad, India n=21 (%)
Gender		
Male	40 (95.2)	21 (100)
Female	2 (4.8)	0 (0.0)
Age groups		
20-39	15 (17.9)	6 (5.8)
40-59	21 (25.0)	11 (10.7)
> 60	6 (7.1)	4 (3.9)
Duration (years)		
1 – 3	4 (9.5)	2 (9.5)
4 – 7	5 (11.9)	1 (4.8)
8 – 11	5 (11.9)	4 (19.0)
12 – 15	3 (7.2)	2 (9.5)
> 16	25 (59.5)	12 (57.2)
Frequency (glasses* per day)		
1 – 2	8 (19.0)	2 (9.5)
3 – 4	25 (59.5)	6 (28.6)
5 – 6	9 (21.4)	13 (61.9)
Type		
Beer	17 (40.5)	1 (4.8)
Stout	11 (26.2)	2 (9.5)
Samsu	14 (33.3)	6 (28.6)
Whiskey	0 (0.0)	13 (61.9)

* each glass contains 900 ml of alcohol

Betel Quid Status Among the Ipoh and Dharwad Group

Slightly more than two thirds (29/84) of the Ipoh respondents had betel quid chewing habit (Table 4). However, the habit was more common among the Dharwad group (71/103). The habit was more common among the females (n=27) in the Ipoh group whereas it was more common among the males (n=54) in the Dharwad group. Majority of the betel quid chewers were over 60 years old (58.6%) in the Ipoh group whereas the habit was more popular among the age range of 20-59 years in the Dharwad group (73.2%). More than one third (34.5%) of the Ipoh respondents chewed betel quid 1-3 times a day, in contrast to Dharwad group, where a higher frequency was reported at 8-11 times a day (n=27, 38%). All the betel quid chewers used a combination of ingredients in their preparation. In the Ipoh group, all the respondents included areca nut, betel leaf and slaked lime in their betel quid

preparation. The similar pattern was noticed among the Dharwad group; however none of them included 'Gambir' as an ingredient. Majority of the Ipoh respondents (65.5%) cited '*cultural norm*' as the main reason for practicing the habit whereas'*socializing*' and '*to feel good*' were the main reasons among the Dharwad group.

Table 4. Data of betel quid users

	Ipoh, Malaysia n=29 (%)	Dharwad, India n=71 (%)
Gender		
Male	2 (6.9)	54 (76.1)
Female	27 (93.1)	17 (23.9)
Age groups		
20-39	0 (0.0)	26 (36.6)
40-59	12 (41.4)	26 (36.6)
> 60	17 (58.6)	19 (26.8)
Duration (years)		
1 – 3	10 (34.5)	9 (12.7)
4 – 7	7 (24.1)	16 (22.5)
8 – 11	4 (13.8)	27 (38.0)
12 – 15	6 (20.7)	9 (12.7)
> 16	2 (6.9)	10 (14.1)
Frequency (per day)		
1 – 3	10 (34.5)	9 (12.7)
4 – 7	7 (24.1)	16 (22.5)
8 – 11	4 (13.8)	27 (38.0)
12 – 15	6 (20.7)	9 (12.7)
> 16	2 (6.9)	10 (14.1)
Ingredients used		
Areca nut	29 (100)	70 (98.6)
Tobacco	25 (86.2)	49 (69.0)
Betel leaf	29 (100)	71 (100)
Slaked lime	29 (100)	67 (94.4)
Gambir	1 (3.4)	0 (0.0)

Knowledge and Perception on Oral Cancer

In Ipoh group, more than half (54.8%) of the respondents had knowledge on oral cancer. However, the percentage was even less among the Dharwad group as only 44.9% known about oral cancer. The primary source of this knowledge was their dentists among the Ipoh group, whereas television was reported as the primary source of knowledge among the Dharwad group.Similar patterns were observed about the perception of oral cancer among the two groups as only 15.5% and 11.7% of the respondents among the Ipoh and Dharwad group respectively felt that they are susceptible to oral cancer.

DISCUSSION

The present study was conducted among the Indians population residing in Malaysia and in India. The two Indian populations were conveniently selected due to well documented high prevalence of oral cancer among this ethnic group. A convenient non-probability sampling method was used for the present study. Every household in the two communities were invited to form the sampling frame. In both the countries, more males were selected compared to females because the females were shy and refused to be interviewed. The survey instrument used in the study was a structured questionnaire which was adapted from previous literature (Zaiton, 2003). In order to facilitate face to face interview, the questionnaire was translated into the Tamil language. Throughout the study, this local language was used to minimize the inaccuracy and to increase the understanding of the questions asked. In both countries, some informational bias could have been introduced through respondents who had under reported their high risk habits. To minimize this problem, a standard interview method was introduced for every respondent.

In both countries, the overall prevalence of high risk habits was found to be very high. In every household where the interview was conducted, at least one respondent cited practicing a habit. In our study, the prevalence of smoking habit among the Ipoh Indians is high (57.1%) compared to what has been reported in the literature. In all three National Health and Morbidity Surveys which have been conducted since 1986, the prevalence of smoking among adults aged 18 and above in Malaysia were more than 20%; i.e. 21.5% in 1986, 24.8% in 1996 and 22.8% in 2006 (National Health and Mobidity Survey, 2008). Similarly, the prevalence of smoking habit among the Dharwad Indians was also found to be high in our study compared to Ikeda's (Ikeda et al,1995) findings which have demonstrated the prevalence to be much lower (15.2%). It is interesting to note that majority of the smokers in both the groups comprised of male subjects, a finding which has been reported in other studies (Zaiton, 2003; Ikeda et al., 1995; Gan, 1995).

It is observed that the prevalence of alcohol use in both the groups is high (Ipoh 50%; Dharwad 24.7%). The published reports on Malaysian population have demonstrated a much lower prevalence of 8.5% (Zaiton, 2003). The findings from the Indian estates have reported a slight higher prevalence of 16.1% (Tan etal, 1998). In both the countries, a higher proportion of the respondents who consumed alcohol were among males. This finding was expected due to the cultural framework of Indian communities where females do not indulge greatly into smoking and alcohol. The most preferred alcohol beverage in the Ipoh group was Beer followed by Samsu, which is the cheapest alcohol and easily available in most sundry shops. However, Whiskey was the most popular alcohol beverage among the Dharwad group. The prevalence of betel quid chewing habit among the Ipoh Indians is found to be 34.5%. This finding is higher compared to the findings of a study conducted in 6 randomly selected Indian communities, whereby out of 628 subjects, 19.3% were betel quid chewers (Tan et al,2000). The high prevalence of betel quid chewers in current study could be attributed to the densely populated Indian community exhibiting their deeply rooted culture and the belief that this habit is a cultural norm inherited from their grandparents from India. Interestingly, only 8 (11.3%) respondents in the Dharwad group cited cultural norm to be the main reason of their practicing the habit. Instead the main reasons reported were socializing (23.9%), to feel good (22.5%) and just for fun (19.7%).

More than half (54.8%) of the Ipoh respondents and 44.9% of the Dharwad respondents reported having knowledge of oral cancer. More so, only 15.5% of the Ipoh Indians and 11.5% of the Dharwad Indians felt susceptible to oral cancer. These findings are approximately similar with those of a study done in Great Britain where author's reported oral cancer to be the least heard of cancers by the public with only 56% of the participants being aware (Warnakulasuriya, 1999). A study carried out on a similar proportion of subjects to evaluate the susceptibility to oral cancer also reported a lower susceptibility rate of 17.3% (Zaiton, 2003). In contrast, (Tan et al, 2000) reported 50.9% of the estate Indians felt susceptible to oral cancer. Surprisingly, most of the subjects still continue to practice their high risk habits despite knowing that their habits are associated with oral cancer.

CONCLUSION

In summary, the prevalence of high risk habits in both communities is still high despite having knowledge on oral cancer. Social lifestyle and environmental changes is necessary to eradicate these high risk habits. Socio-cultural backgrounds need to be changed to support individuals to choose healthier lifestyles and high risk preventive strategies need to be implemented to modify or change their behaviors so as to reduce the prevalence of these high risk habits.

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MALAYSIAN OVERSEAS POSTGRADUATE CANDIDATES' ROLES IN MALAYSIA FUTURE DEVELOPMENT

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ABSTRACT

Malaysia is currently undergoing a transitional stage that will shape its future direction. Malaysian overseas postgraduate candidates are an important component of this transitional stage. Research and human capital and social development are two potential areas whereby postgraduate candidates may contribute significantly to the country future development. This articles focuses on how Malaysian overseas postgraduates could effectively capitalise valuable resources and opportunities available to them while studying in overseas institutions in the context of the two potential areas. Effective capitalisation of the resources and opportunities would enhance their capacity to contribute to the country's future development.

Keywords: Malaysia, overseas postgraduates, universities, future development

INTRODUCTION

Malaysia is currently undergoing a transitional stage that will shape its future direction. This includes the focus on the Economic Transformation Program (ETP) that will transform Malaysia into a high-income nation in 2020. According to the World Bank Chief Economist, Kaushik Basu "If Malaysia continues its efforts in diversifying its economy and moving into high-end manufacturing, as well as continue to stress high education and human capital formation, then it is capable to achieve its high income nation targets" (Basu, 2013). Transforming Malaysia from middle income nation into a high income nation is a momentous effort that requires support from all Malaysian, including those who are currently undertaking postgraduate studies in universities all over Australia. In fact, Malaysian overseas postgraduate candidates are an important component of Malaysia future development, especially in relation to high education and human capital development.

In 2012 there were 40,000 candidates underdoing PhD at public and private universities in Malaysia compared to only 4000 candidates in 2002 (Bernama, 2013). It is a tenfold increase in the number of PhD candidates in Malaysia within 10 years. Only selected few have the opportunity to do their PhD in overseas universities. It goes without saying that there are countless advantages of undergoing postgraduate studies in overseas universities, including in Australia. In general, studies in overseas institutions allow postgraduates to gain valuable experience, knowledge, expertise, mentoring and network that may not be available in Malaysia. These valuable resources would enhance postgraduates' capacity to contribute to the future development of the country. Hence, it is imperative that postgraduates capitalise on the vast opportunities available to them while they are in overseas so that their qualification from overseas institutions is not just a about piece of paper. In the context of this conference, let us look at two potential

areas whereby postgraduate candidates may contribute significantly; (i) Research; (ii) Human Capital and Social Development. The purpose of this paper is to discuss the Malaysian overseas postgraduate students' roles and responsibility for the development of the country.

RESEARCH AND DEVELOPMENT

In terms of research, first, I would like to draw your attention to Suntech Power Holdings Limited, one of the world's biggest solar panel manufacturers. There are a number of interesting facts about this company that each of us should know. First, the founder, Shi Zhengrong, who is the world's first solar billionaire, did his PhD at the University of New South Wales, Australia. He founded Suntech in 2002. Second, he was supervised by Professor Martin Green, world's leading researcher in solar technology. Third, Zhengrong has been instrumental in developing solar panel manufacturing industry in China, in particular, low cost solar manufacturing. Fourth, he blends Australian intellectual property with China's manufacturing base to develop solar manufacturing business on a global scale. If we look closely at Zhengrong's successes, it clearly involves an effective capitalisation of valuable experience, knowledge, expertise, mentoring and network in Australia that are not be available in China when he first start solar panel manufacturing in the country.[1] It also proves the importance of having human capital with overseas exposure in various fields in fostering nation's development. Second, as higher education in Malaysia moves towards global recognition, universities are encouraging academics to become research active by publishing their research in international journals. While in overseas, postgraduates should attempt to understand the best practices and cultures in top overseas universities in regards to research and publication. One of the key characteristics of the best practices in these top universities is their emphasis on quality of research and publication, instead of mere emphasis on quantity. Undeniably anecdotal evidence shows that a number of academics in Malaysian universities managed to conduct high quality research and publish in top quality journals. However, the numbers are far below than other top universities in the region let alone in the world. Key Performance Index (KPI) in some universities that focuses too much on quantity of publication could indirectly push academics in Malaysia to concentrate their effort on publishing the required number of publication in a year, instead of focusing on the quality of publication.

To develop research and publication culture that truly focuses on quality instead of mere quantity in our academic institutions is not an easy endeavour. It requires considerable effort and may take many years. Each and every parts of the system, especially university leadership at various levels and academics must be willing to think and work along the same continuum, i.e., to give a strong focus on quality. As majority of current postgraduate candidates will be future leaders in Malaysian universities, it is vital that they learn and understand the best practices and cultures in research and publications from the best institutions in overseas. Persistent focus on quality of research and publication not only enhance the reputation of Malaysian universities in the global arena but more importantly contribute to the future development of the country.

[1] For further reading, refer to Knight (2011).

HUMAN CAPITAL AND SOCIAL DEVELOPMENT

There are also ample opportunities for Malaysian overseas postgraduates to contribute to the human capital and social development of the country. Every year, around 180,000 students graduate from institution of higher learning in Malaysia. However, one of the issues that has been highlighted for quite sometimes by the industry is the employability of these graduates. In addressing this issue, the Ministry of Education has published The National Graduate Employability Blueprint 2012-2017. There has been concern among employers that most of the graduates are lack of soft skills, in particular, critical thinking skills. A closer look at employability of graduates in Australia and other developed nations indicates that lack of critical thinking among graduates is not a major concern. Hence, there are things to be learned from higher education institution in these countries, especially those related to teaching approach, pedagogy, assessment as well as the use of technology in teaching. Malaysian overseas postgraduates should ask themselves to what extent they understand or familiar with the undergraduate teaching in their university? It is important that overseas postgraduates take a proactive approach in finding ways to understand teaching and learning framework used in the universities they are currently studying at. There are many avenues to achieve this including by teaching at the university as a casual tutor or enrolling into free teaching and learning program for postgraduates offered by the university. Although these require diversion and reallocation of time and efforts from research, in the long run, the benefits to be gained far exceed the costs. Should postgraduates are unable to do any of those, in the worst case scenario, they should take initiative to interact with undergraduate students in their respective discipline and understand the assessment and teaching approach used by the students' lecturers. By doing these, Malaysian postgraduates in overseas will become more resourceful; hence allow them to contribute greatly in enhancing critical thinking skills and employability of future graduates in Malaysia.

Current Malaysian overseas postgraduates will soon become "opinion leaders" in Malaysia. Like it or not, culturally, those with high qualification are highly respected by Malaysian. As "opinion leaders", they have some influence in the society. There are lots of positive examples that Malaysian postgraduates studying in overseas can learn from the ways of life and attitudes of people in developed countries. It would be beneficial to the country if the postgraduates could become "agent of change" by adopting those positive values as part of Malaysian ways of life. Although these looks like a simple contribution, but we need to start somewhere. Having "opinion leaders" as "agent of change" could contribute to the development of future Malaysia as a country with first-class facilities and first-world mentality.

CONCLUSIONS

Malaysian overseas postgraduates can contribute to future development of Malaysia in many ways, in particular in terms of research and human capital and social development. Furthering studies in overseas academic institutions allows Malaysian postgraduates to gain valuable experience, knowledge, expertise, mentoring and network that may not be available in Malaysia. It also provides opportunities for them to understand research and publication cultures of top overseas universities. In addition, postgraduates should proactively look for opportunities to understand teaching and learning framework used in the overseas academic institutions. As current overseas postgraduates will soon become "opinion leaders" in Malaysia, they should act as an

effective "agent of change" by adopting positive values learned in overseas as part of Malaysian way of life. Overall, effective capitalisation of valuable resources and opportunities available while they are in overseas would enhance Malaysian overseas postgraduates' capacity to contribute to the country's future development.

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THERMAL DEGRADATION STUDY OF KENAF FIBRE/EPOXY COMPOSITES USING THERMO GRAVIMETRIC ANALYSIS

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ABSTRACT

Kenaf fibres are receiving much attention in the natural fibre composite industry due to its potential as polymer reinforcements. However, like all natural fibres, kenaf fibres have lower thermal resistance as compared to synthetic fibres. In this current work, the characteristics of kenaf fibre/epoxy composites, both treated and untreated using alkalization process, exposed to high temperature were studied. Thermo gravimetric analysis (TGA) was used to study the thermal decomposition behaviour of treated and untreated kenaf fibre/epoxy composites, glass fibre/epoxy composite as well as neat epoxy from room temperature up to 600 ºC. Surface morphology of both kenaf fibre/epoxy composites after exposure at 100 ºC was observed using scanning electron microscopy (SEM). The results from the TGA showed that the addition of kenaf fibres into the epoxy slightly improves both the charring and thermal stability of the samples. However, it was observed that alkalization of fibres causes reduction in these behaviours. At 100 ºC, the SEMs show more voids in the untreated composites than the treated ones, suggesting higher moisture content within the voids which influences the higher weight loss of untreated composite at this temperature.

***Keywords*:** natural fibres composites, kenaf fibre, thermal degradation, Thermo Gravimetric Analysis (TGA).

INTRODUCTION

Fibre reinforced polymer composite or more easily referred to as FRP is a relatively new material in the construction industry as compared to steel and concrete (Awad et al., 2012). The commonly used synthetic fibres are glass, aramid and carbon (Hollaway, 2010). However, these fibres face some competition from natural fibres due to the emerging concept of green-building. The advantages of natural fibres over its synthetic counterparts include low weight, low cost, low density, biodegradable, availability from renewable resources, and good thermal and acoustic insulation properties (Dittenber and GangaRao, 2012, Liu et al., 2012, Araújo et al., 2008). Also, they are non-abrasive on processing equipments and provide safer and healthier working environment (John and Thomas, 2008). What makes natural fibre appealing as a composite reinforcement material is its biodegrdability which can contribute to the reduction of construction waste (Dittenber and GangaRao, 2012) thus reduces landfill dependency. However, this very attraction also imposes a great drawback on its durability. The disadvantages of natural fibre includes the incompability between fibre and polymer, low moisture resistance, inferior fire resistance, limited processing temperature, lower durability, and variation in quality and price (Dittenber and GangaRao, 2012, Araújo et al., 2008). Presence of hydroxyl groups in natural fibres makes them hydrophilic in nature and this

causes incompatibility with the hydrophobic polymer matrix (Araújo et al., 2008, Dittenber and GangaRao, 2012, Shih, 2007, Chen et al., 2009). The hydrophilicity of natural fibres leads to low interfacial strength and generates high moisture absorption that causes composites to fail in wet condition through fibre swelling and delamination (Joseph et al., 2002, Assarar et al., 2011). In terms of exposure to high temperature, majority of natural fibres have low degradation temperatures which are inadequate for processing with thermoplastics with processing temperatures higher than 200°C (Araújo et al., 2008).

The major issue that hinders the widespread use of FRP in structural engineering application is the degree of fire resistance of the material and the limited amount of information regarding FRP behaviour in fire. At lower temperature of 100-200 °C, FRP soften, creep and distort causing buckling for load bearing structures while at 300-500 °C, polymer matrix decomposes, releasing heat and toxic volatiles (Hollaway, 2010). Decomposition of burning polymers includes the production of combustible gases, non-combustible gases, liquids, solids (usually char), and entrained solid particles (smoke). These outcomes may produce hazards such as the evolution of toxic gases (in the case of PVC), loss of physical integrity, and melting and dripping thereby providing other ignition sources (in the case of polyolefins and polyethylene) (García et al., 2009, Stark et al., 2010).

For natural fibres, flammability is in part due to differences in chemical composition. Higher cellulose content results in higher flammability while higher lignin content results in greater char formation with lower degradation temperature (Dittenber and GangaRao, 2012, Manfredi et al., 2006, Suardana et al., 2011). Char formation is important during a fire as it protects core of material and structural integrity. Other attributes that provide better fire performance includes the present of silica or ash and higher crystallinity and lower polymerization of fibre microstructure (Dittenber and GangaRao, 2012). Among the natural fibres studied, flax fibres are considered the best for thermal resistance due to their low lignin content (Manfredi et al., 2006).

Temperature plays an influential role in the thermal stability of natural fibre composite where it causes direct thermal expansion or contraction and affects rate and volume of moisture absorption that leads to fibre swelling (Wang et al., 2005). The degradation process of natural fibres includes dehydration combined with emission of volatile components initiating at a temperature of about 260 °C, and rapid weight loss due to oxidative decomposition corresponding to the formation of char as the temperature increased (Beg and Pickering, 2008). Thermo gravimetric analysis is one of the methods used to study the thermal degradation behaviour of natural fibre/polymer composites and its constituents. Approximately 60% of the thermal decomposition of most natural fibres occurred within a temperature range between 215 and 310 °C with an apparent activation energy of 160-170 kJ/mol (Yao et al., 2008). For example, fibres from water hyacinth, reed, sisal and roselle decompose at 290-490 °C (Methacanon et al., 2010) while bamboo fibres degrade at 250-420 °C (Lee and Wang, 2006). In this current work, investigation was carried out to study the degradability behaviour of kenaf/epoxy composite exposed to high temperature in comparison with neat epoxy. The effect of alkalization treatment on the thermal degradation of kenaf fibre/epoxy composite was also observed. It is important to analyse the behaviour of natural fibre/polymer composite subjected to thermal exposure in comparison to its synthetic counterpart in order to draw a conclusion to whether natural fibres are technically capable to replace synthetic fibres.

EXPERIMENTAL DETAILS

Materials Selection

Raw kenaf fibres were supplied by Malaysian Agricultural Research and Development Institute (MARDI). The fibres were socked in warm water for 3 hours and then rinsed with tap water to remove any dirt or debris. The colour of the rinsed water was monitored to ensure that the fibres were cleaned thoroughly. The fibres were combed and then dried for 24 hours in an oven at a temperature of 40 ^{o}C. In the fibre treatment process, the cleaned kenaf fibres were cut into an average length of 100 mm. Sodium hydroxide (NaOH) solution was prepared with a 6wt% concentration. The selected fibres were immersed in NaOH aqueous solution for 24 hours at room temperature. After treatment, the fibres were thoroughly washed with tap water until all traces of NaOH were removed from the fibres and then dried for 24 hours in an oven at a temperature of 40 ^{o}C. The resin used in the current work is liquid epoxy (DER 331) which is a liquid reaction product of epichlorohydrin and disponol A. It is suitable for applications such as casting and tooling, composites, and automotive parts. The curing agent used for the selected epoxy is JOINTMINE 905-3S, which is a low viscosity aliphatic amine for room temperature curing. It has good wetting properties and impact resistance.

Epoxy Composites Preparation

In the fabrication process, the epoxy resin and hardener, with a ratio of 2:1, was uniformly mixed using an electric mixer and poured into the desired mould. The mould was placed in a vacuum chamber (MCP 004PLC) with a 0.5 bar pressure to get rid of any air bubbles which may have been trapped in the mould in between the fibres. The vacuumed block was kept for curing at room temperature for 24 hours. The volume fraction of the fibre in the matrix was controlled to be about 48% Vol.

Thermal Gravimetric Analysis

Thermal gravimetric analysis was conducted using TGA Q500 machine. Samples weighing approximately 10mg were subjected to pyrolysis in nitrogen environment to a maximum temperature of 600 °C at a heating rate of 10 °C/min. The weight loss was recorded in response to increasing temperature, with final residue yield on set of degradation temperature and number of degradation steps reported. Additionally, glass fibre/epoxy composite sample was also tested for comparison.

Scanning Electron Microscopy

Rectangular cubes of treated kenaf fibre/epoxy composites and untreated kenaf fibre/epoxy composites with the dimensions of 10x10x15 mm were prepared. Samples were placed into a laboratory muffle furnace and were heated to maximum temperatures of 100°C at a heating rate of 5 °C/mi for 1 hour. Scanning electron microscopy was performed using JEOL JCM-6000 with a balance scale range of ± 0.1µg. The samples were coated with gold prior to conduction and the final morphologies of the samples were examined.

RESULTS AND DISCUSSION

Thermal Decomposition through Thermo Gravimetric Analysis

Figures 1 and 2 shows the TGA and DTA curves obtained from the runs. The data from both curves were extracted and presented in Table 1.

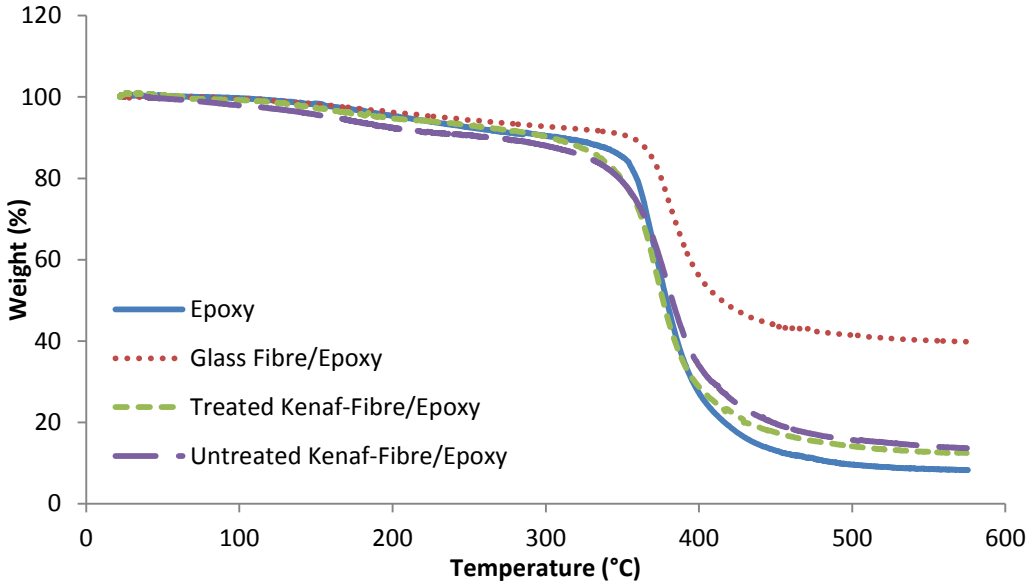

Figure 1. Thermo Gravimetric Analysis (TGA) curves

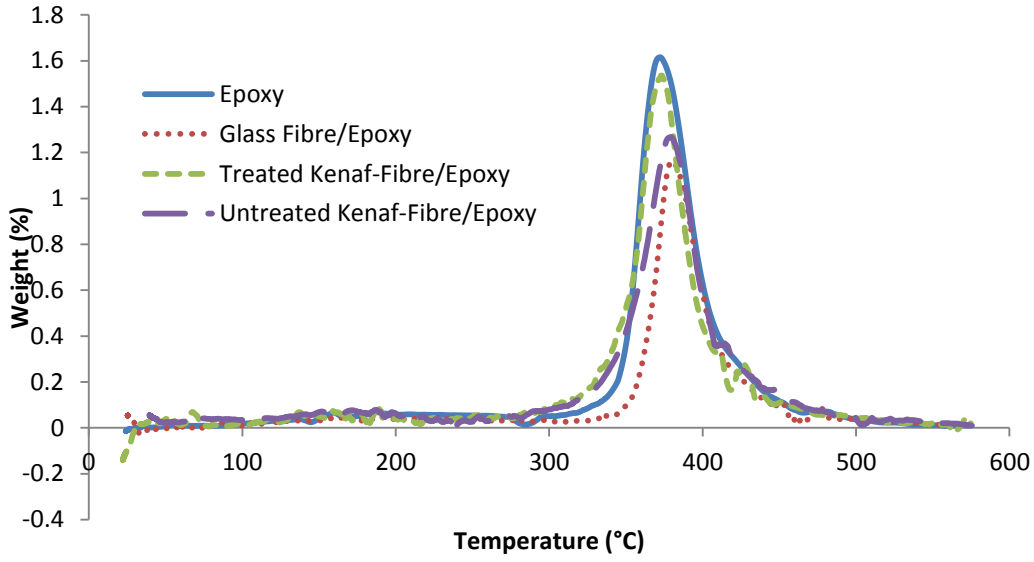

Figure 2. Differential Thermal Analysis (DTA) curves

Table 1. Decomposition temperature and charring of samples for epoxy and its composites.

Alkali Treatment (wt.%)	Epoxy	Glass Fibre/ Epoxy	Treated Kenaf-Fibre/Epoxy	Untreated Kenaf-Fibre/Epoxy
Decomposition Temperature (°C)	371.99	380.12	373.47	378.64
Final Weight after Decomposition (%)	8.29	39.83	12.46	13.67
Increment in Thermal Stability (%)	-	2.19	0.40	1.79
Increment in Char Production (%)	-	380.46	50.30	64.90

From Figure 1, it can be seen that the untreated kenaf/epoxy composite starts to lose weight earlier than the other samples. This is attributed to the higher moisture content of untreated fibres whereby, the presence of hemicelluloses has caused higher moisture absorption of the composite (Methacanon et al., 2010). Moisture evaporates from the fibres starting at 80 ºC. The percentage of weight reduction at 500°C reflects the amount of residues left after the composites were degraded. Epoxy has the lowest residue due to the absence of char. Treated kenaf/epoxy composite had lower residue than untreated kenaf/epoxy composite due to the removal of lignin through alkalization. Lignin in kenaf is responsible for charring thus untreated kenaf/epoxy composite will have more char (Beg and Pickering, 2008). The peaks of the DTA curves correspond to the decomposition temperature of each constituent of the composites. However, from Figure 2, only one peak is obvious for all curves due to the overlapping peaks of the fibres and epoxy (Azwa et al., 2013). It seems that neat epoxy has the lowest decomposition temperature at 371.99 ºC while the addition of fibres had shifted the curves to higher temperatures. Some researchers have found that the addition of natural fibres causes reduction in the thermal stability of the composite due to the influence of the less stable fibres (Lee and Wang, 2006). It seems that in this study, the kenaf fibre plays a synergistic role in improving the thermal resistance of the composite. The charring provided by the degradation of the kenaf fibre may have contributed to this. Further investigation is needed to explain this behaviour.

Treated kenaf-fibre/epoxy is less stable than the untreated ones. This contradicts some studies that states that with the reduction of hemicelluloses and lignin from fibre treatment, thermal stability is increased (Methacanon et al., 2010, Beg and Pickering, 2008). However, through alkalization, cell walls of fibres are removed which may reduce the thermal protection of the treated fibres. Also, the exposure of cellulose to direct heat without any layering from the cell walls and hemicelluloses may contribute to this lack in thermal stability. This hypothesis is based on reports suggesting that flammability of natural fibres is contributed by its cellulose content (Suardana et al., 2011). As expected, glass fibre improved the thermal resistance of the composite the most and gives a charring structure at the end of the test.

Morphology of Composites through Scanning Electron Microscopy

To study the reason on why untreated kenaf fibre/epoxy composite lost its weight at a lower temperature than the other samples, its morphology was observed using scanning electron microscopy (SEM) and compared to the treated sample. The SEM observations

reflect the results of the weight loss of the samples as discussed earlier. Figures 3 and 4 represent the micrographs of treated and untreated composites at 100 ºC, respectively.

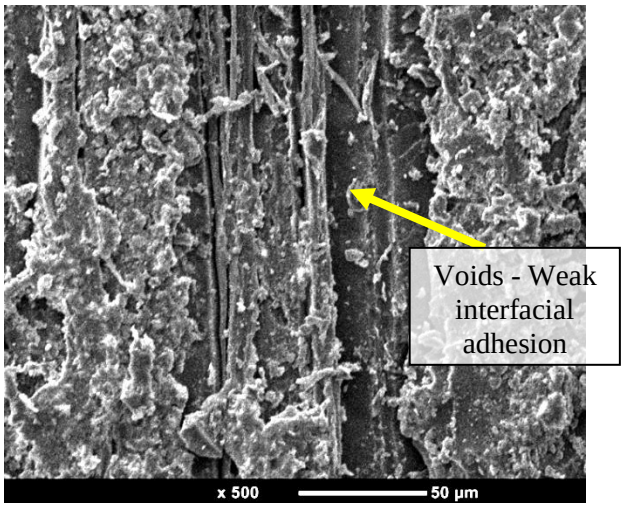

Figure 3. Micrograph of untreated kenaf/epoxy composite at 100 ºC.

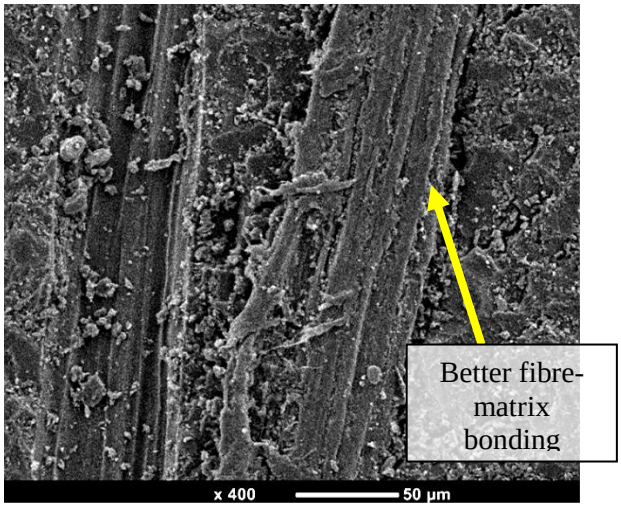

Figure 4. Micrograph of treated kenaf/epoxy composite at 100 ºC.

For the untreated kenaf-fibre/epoxy composites, it is obvious that more voids are present along the fibre-matrix interface, as shown in Figure 3, suggesting week interfacial adhesion. These areas provide spaces for moisture to occupy thus making untreated kenaf composites more vulnerable to moisture attack as compared to the treated ones (Azwa et al., 2013, Dittenber and GangaRao, 2012, Chen et al., 2009), which explains its higher initial weight loss. At lower temperature, treated kenaf-fibre/epoxy composite has better fibre/matrix bonding due to the removal of hydrophobic components of the fibre, allowing better compatibility between the kenaf fibre and the epoxy. This compatibility provides better interfacial adhesion and mechanical interlocking between the fibres and the matrix as observed in Figure 4, whereby the fibre surface is seen to be filled up by the epoxy. This improves the resistance of the composite to moisture thus, the lack of moisture leads to comparable percentage of weight loss to epoxy at temperature below 300 ºC.

Observations on bamboo fibres at various degrees of alkalization was conducted by Wong et al. (2010) through SEM and it was discussed that the present of voids suggest that impurities and soluble substances were gradually removed as the concentration of alkali is increased. This increased in surface area provides more interface for fibre/matrix adhesion and with the absence of the hydrophilic component of the fibres, the resin has a better chance to seep through and bound with the fibres. Such improvement was also observed for treated kenaf fibres alone whereby the morphological changes provided better tensile strength and modulus of the fibres (Yousif et al., 2012). SEM studies were performed on tensile-tested coir/polyester composites which highlighted that the treated coir fibres showed a reduction in fibre pull-out with better dispersion of matrix in the fibres as compared to the untreated coir fibres (Rout et al., 2001). This is in agreement with Figure 4.

CONCLUSION

Treated and untreated kenaf fibre/epoxy composites, glass fibre/epoxy composite as well as neat epoxy were subjected to thermal degradation by means of Thermo Gravimetric Analysis (TGA). From this study, it can be concluded that the addition of fibres into the epoxy improves the thermal stability of the samples as well as its charring capability, with glass fibres giving the best results. However, alkalization reduces the decomposition temperature of the kenaf fibre/epoxy composite and produces lesser char than untreated composite caused by the removal of lignin. Through SEM, it was confirmed that weak fibre-matrix adhesion of the kenaf fibre with the epoxy causes high moisture content of the composite which was removed at a temperature of 80 ºC.

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FINANCIAL EXCLUSION IN AUSTRALIA: AN EXPLORATORY CASE STUDY OF THE MUSLIM COMMUNITY

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ABSTRACT

Nearly 3 billion people in the world faced the difficulties in accessing formal financial services and products which alerted on the issue of financial exclusion. Financial exclusion refers to a situation where individuals lack access to appropriate and affordable financial services and products. In 2012, approximately 3.1 million of the Australian adult populations are identified to be financially excluded. The study of financial exclusion is highly important for the nation and society because consequences of financial exclusion are detrimental to the economy. The purpose of this paper is to explore the nature and extent of financial exclusion faced by the Muslim community in Australia. This paper is based on literature reviews, secondary data and the authors' personal experience in association with banking industry, as the research is in the progress of data collection. The initial finding of this paper concludes that there is still lacking of information about financial exclusion according to ethnicity or religious group in Australia. It also appears that very limited financial institutions in Australia that is offering Islamic financial services and products to cater for the needs of some 476,000 Muslims in Australia. These Muslims communities may have been financial excluded due to their faith and religious belief, because Islam prohibits *Riba* (usury and/or interest) as widely practiced in conventional banking and finance operations.

Keywords: Financial exclusion, Muslims, Australia

INTRODUCTION

Financial crises have profound economic and social consequences. They tend to induce what the financial-services industry describes as a 'flight to quality'; that is, a search for 'safer' markets, a process which tends to be in favour of the more affluent and powerful social groups and against the poor and disadvantaged groups. Financial exclusion refers to a situation where individuals lack access to appropriate and affordable financial services and products. Nearly 3 billion people in the world faced the difficulties in accessing formal financial services which alerted on the issue of financial inclusion (Kumar & Mishra 2011). A good financial system serve a vital purpose, offering savings, credit, payment, and risk management products to people with a wide range of needs. Financial systems that allow broad access to its services, without price or non-price barriers to their use are especially likely to benefit the disadvantaged groups including the poor. Without inclusive financial systems, these groups of people must rely on their own limited savings to invest in their education or become entrepreneurs and small enterprises must rely on their limited earnings to pursue promising growth

opportunities. This can contribute to persistent income inequality and slower economic growth (Simpson & Buckland 2009).

Although the researcher is unable to locate any specific research conducted on faith-driven financial exclusion in Australia, the existence of the problem can't be denied as suggested by some commentators (Burkett & Sheehan 2009; Pearce 2010). In another context, Bhalla and Lapeyre suggested that research on social and financial exclusion can and should be done at different spatial scales whether individual or social groups including women, minorities, ethnic groups, etc. (Bhalla & Lapeyre 1997). Connolly et el. (2011) recommended that a further research be conducted on the barriers to financial inclusion faced by persons born overseas in particular from non-English speaking countries; this category of people would include the Muslim community that came to Australia for various reason. This study will focus on the issue of financial exclusion faced by the Muslim community in Australia and explore the path towards improving their financial inclusion level.

FINANCIAL EXCLUSION

Leyshon and Thrift proposed the first definition of financial exclusion. According to the authors, financial exclusion involves the "processes that serve to prevent certain social groups and individuals from gaining access to the financial system" (Leyshon & Thrift 1995). The study emphasized on the role of geographical exclusion, e.g. the difficulties experienced by certain individuals in accessing financial services because of the lack of a bank branch in their area or because of the closure and relocation of a branch. Subsequent research studies adopted this "in and out" approach but explored other causes which explained access difficulties (Devlin 2005; Kempson 2001; Sinclair, P. 2001). The study emphasized that difficulties of access can also be explained by condition exclusion (e.g. requirements to access financial products are inappropriate), price exclusion (e.g. services are costly), marketing exclusion (e.g. information about new products is not displayed to non-desirable customers), self-exclusion (e.g. people do not access financial products because of fear or distrust of banks or because they have already been refused).

The European Commission (EC) defines financial exclusion as a process whereby people encounter difficulties accessing and/or using financial services and products in the mainstream market that are appropriate to their needs and enable them to lead a normal social life in the society in which they belong (Commission 2008). Although the term 'normal social life' was not explicitly explain how far financial inclusion policies should go, the EC's definition, and the fact that financial exclusion has been expressly incorporated in its poverty and social exclusion agenda, represents a step ahead of the more restricted focus on individual 'accession' to the mainstream financial system. In another study, it was highlighted that financial exclusion is attributable to an intersection of migrant status with several disadvantages such as gender, ethnic and racial inequalities, as well as immigration status and labour market position (Datta 2009). It was also reported that Muslim communities may have faced financial disadvantages because of their faith and religious belief which make them financially excluded from the mainstream financial systems (Pearson 2008).

In the UK, where financial inclusion has been part of the policy agenda for more than a decade (Kempson & Whyley 1999), some 1.75 million adults still lacked access to a transaction account (Taskforce 2010). Increasing access to the mainstream system through a bank account was one of the primary tasks of the financial inclusion strategy

initiated in 2004 which targeted access to banking services, affordable credit and face-to-face financial advice. These initiatives were complemented by policies to stimulate asset building. In a study on financial exclusion in Canada, the author defined financial exclusion as the situation faced by people who have no relationship or insufficient relationship with the mainstream financial institutions to meet all their financial service needs (Buckland 2012). The said study examined financial exclusion among low-income people in inner cities and the resulting hard choices they need to make about their banking. As a consequence, the study found that many people rely for all or a portion of their financial services on fringe banks such as cheque cashers and pawn-shops.

In a policy research working paper published by the World Bank in 2012, Mexico seriously lags behind in financial depth and inclusion by both international and regional standards. It was reported that only 27.4% of adults had an account at a formal financial institution (Demirguc-Kunt & Klapper 2012), just below Bolivia's 28.0%; a country with a GDP per capita one fifth that of Mexico (Cull et al. 2013). Hence, the report is in conformity that financial exclusion is indeed a global issue. The article by Sinclair (2013) discussed from a knowledge exchange review of financial inclusion in Britain and compares to key features of financial exclusion evident from European analyses. The research identified agreement among British stakeholders over several aspects of financial exclusion, in particular continuing problems of access to mainstream banking services for low income customers and a lack of appropriate and affordable credit provision. Areas of controversy included whether banks denied services to lower income customers or were withdrawing from deprived communities, and the necessity for further regulation of mainstream financial services (Sinclair 2013). Levels of financial exclusion vary between developed and the developing countries, however various studies have confirmed that it is the same group of people who are always financially excluded. The mostly cited financially-excluded groups include the long-term unemployed or those with unstable work patterns, the elderly with no or few assets, lone parents who cannot work due to family commitments, people without educational qualifications and the financially illiterate, ethnic minorities and immigrants where community influence leads to financial exclusion, driven by cultural and religious factors, people who live in deprived neighbourhoods with high levels of crime and people with a history of bad debt.

The importance to study financial exclusion

Development economist suggested that the lack of access to finance contributes to the slow growth in economic development (Mohieldin 2011). The main reason why finance matters is because financial development and intermediation has been shown empirically to be a key driver of economic growth and development of a nation. Economic growth needs to be sufficiently inclusive so that the benefits can be shared among all, or else the growth process itself shall be jeopardized and derailed (Burkett & Drew 2008). Modern development theory studies the evolution of growth, relative income inequalities, and their persistence in unified models. The evolution of financial development, growth, and intergenerational income dynamics are closely interrelated. Finance influences not only the efficiency of resource allocation throughout the economy but also the comparative economic opportunities of individuals from relatively rich or poor households (Joassart-Marcelli & Stephens 2010). Improving access and building inclusive financial systems is a goal that is relevant to economies at all levels

of development. The challenge is greater than ensuring that as many people as possible have access to basic financial services (Howell 2008; Smyczek & Matysiewicz 2012). It is just as much about enhancing the quality and reach of credit, savings, payments, insurance and other risk management products in order to facilitate sustained growth and productivity, especially to combat financial exclusion.

Financial exclusion holds back its victims from progress and development by imprisoning them in a vicious cycle of social deprivation and poverty. It is impossible to measure the overall impact of financial exclusion on the excluded due the complex nature of this problem but wider implications of financial exclusion include social and financial consequences that have a detrimental effect on the excluded. In addition, financial consequences affect the way people access financial services as well as how they use them, whilst social consequences have a larger impact due to their effect on the consumer's overall economic and social behaviour

Overview of financial exclusion in Australia

Before we delved into the financially excluded in Australia, it is essential to highlight two limitations. The first limitation is that financial exclusion is not static but can occur at particular periods of the life course and in different areas of finance, statistical data will always fall short of capturing the complete picture. The second limitation refers to the lack of disaggregated and updated statistics that would allow a detailed analysis and monitoring of financial exclusion across time (Arashiro 2010).

The most frequently cited definition of financial exclusion in Australia was developed by Connolly & Hajaj who stated that "it is a lack of access to financial services by individuals or communities due to their geographic location, economic situation or any other 'anomalous' social conditions which prevents people from fully participating in the economic and social structures of mainstream communities" (Connolly & Hajaj 2001). In a report by Chant Link & Associates (commissioned by ANZ), a new definition of financial exclusion was developed that considered access, as well as an assessment of whether products were appropriate or affordable, and also making a connection between financial exclusion, income and hardship.

> *Financial exclusion is a lack of access by certain consumers to appropriate, low cost, fair and safe financial products and services from mainstream providers. Financial exclusion becomes of more concern in the community when it applies to lower income customers and/or those in financial hardship. Financial exclusion is observable at individual, family, or household level, but can also be heavily concentrated in suburbs or regions, and sometimes among ethnic minorities in a suburb or region. Financial exclusion can also apply to individual small businesses, NFPs [not for profits] and other community enterprise organisations* (Associates 2004).

The above definition represented a significant shift in understanding financial exclusion in Australia, suggesting that it is broader than ownership of products. In particular, the definition makes a connection between the lack of access to appropriate products and a negative impact for people on low incomes or in financial hardship. It is also significant that the definition implies that mainstream providers should make appropriate products available to address financial exclusion.

The study by Ingrid Burkett and Belinda Drew (2008) tend to suggest that financial institutions believe (not always with evidence) that there are higher costs associated with providing services to low income groups – particularly transaction costs.

They raise the point that lending money to the poor is high risk and doing business with them at all poses greater brand and reputation risks. It was also highlighted that the development of specific and independent Community Development Finance Institutions could make a significant contribution to addressing this exclusion. While most definitions have focused on the exclusion of individuals, this report argues that exclusion extends to non-profit organizations, social enterprises and micro enterprises. The authors also argue that, while regulation in Australia has been important for transparency, it has led to a highly uniform framework for financial services and products which has put pressure on smaller and more specialist companies. "Credit unions with a focus on serving remote indigenous communities and small rural areas have merged with larger institutions that may not have the same orientation to addressing the needs of their members. And small funds with more social and ethical missions have disappeared, as size begins to matter," they said (Burkett & Drew 2008).

In May 2011 The Centre for Social Impact (CSI) published Australian first report on measurement of financial exclusion as commissioned by National Australia Bank (NAB). According to the measurement, approximately 15.6% or 2,650,000 of adult population in Australia were either fully excluded or severely excluded from financial services in 2010. This figure comprises 0.8% of adults who were fully excluded (they had no financial services products) and 14.8% of adults who were severely excluded (they only had one key financial services product) (Connolly et al. 2011).

CSI's definition of financial exclusion is 'where individuals lack access to appropriate and affordable financial services and products'. Among the key financial services and products are a transaction account, a moderate amount of credit and general insurance. A brief description on the financial services and products as reported by CSI is as follows:

- Transaction account – access to a transaction account is seen as a universal need in most developed societies. Since it is the most popular and generalised financial product, the lack of it can stigmatise individuals and promote social exclusion. Essentially, a transaction account is the key to accessing other financial services.
- Moderate amount of credit – credit is a major financial tool to enable access to goods or services that are beyond the monthly budget such as vehicles and furniture. It can also play a significant role in smoothing consumption and protecting against income shocks and financial assets.
- General insurance – it is a way for individuals to protect their key assets and manage risk. Insurance in particular home and contents and motor vehicle insurance is regarded as a significant financial product that provides a personal safety net for individuals or households when facing a range of risks, such as burglary, natural disaster and accidents.

In the same report, it was recommended that there is a need to conduct further research on the barriers to financial inclusion faced by persons born overseas in particular from non-English speaking countries (Connolly et al. 2011). This category of people would include the Muslim community that came to Australia for various reasons from many parts of the world. They may have faced financial disadvantages because of their faith and religious belief which in turn makes them financially excluded from the mainstream financial systems (Pearson 2008). In another literature that was reviewed, it was reported that there is a lack of financial systems in Australia to meet the needs of

the Muslim community who have particular beliefs about the charging of interest (Burkett & Sheehan 2009). In countries where Islamic Finance does not have a presence, it is common to observe that a substantial segment of the Muslim population would refrain from using the conventional banking facilities in order to avoid dealing with usury or interest (*Riba*) due to religious principle (Mohieldin 2011; Pearce 2010).

Often being said in the literature that financial exclusion is very much located at the heart of social exclusion (Scutella 2009; Scutella & Wilkins 2010), there are some social repercussions that can be directly attributed to financial exclusion. For example, financial exclusion denies a segment of the society the opportunity to be active and productive members of the community and thus impedes them from fully integrating and contributing to the well-being of the nation in which they live. This in turn will create other social problems, such as lack of social cohesion and/or integration and the social groups affected will be pushed further into the poverty trap. Moreover, financial exclusion has a detrimental effect on how people run their lives and puts them in a very difficult position where they feel that they have lost control of their lives, causing anxiety and bringing about severe personal and community consequences. In summary, despite having one of the most diverse financial services sectors in the world, financial exclusion in Australia remains a reality for many people. The numbers of Australian population who are financially excluded (no matter what degree of exclusion) are increasing for the past three years. Without access to financial systems, the conduct of everyday life of an ordinary man within a contemporary capitalist society can become extremely problematic.

Causes of financial exclusion

There is no one common reason for financial exclusion. However, there are several factors that definitely act as catalysts for this phenomenon, including the restriction of physical access due to banks closures in disadvantaged neighbourhoods, higher charges for services required by the poor, inappropriate products and biased marketing strategies (Sinclair, S. 2001). Some commentators who focus on the macro aspect of the problem say the major causes of financial exclusion include low income, unemployment, irregular and/or casual work, lack of financial literacy, poor financial habits and geographical remoteness. However, it is generally agreed that the causes of financial exclusion are very complex and differs over time. According to a comprehensive report compiled by the Financial Services Authority in UK: "The problem of financial exclusion has, ironically, resulted from increased inclusion that has left a small minority of individuals and households behind" (FSA 2000). Another reason for financial exclusion, according to some commentators, relates to the competitiveness of the financial services industry where the providers of financial services view people on low incomes as unworthy of their services, thus resulting in a minority of the population having needs unmet by the competitive financial services market (Kempson 2001).

One particular type of financial exclusion that will be covered in this study is faith or religion-driven financial exclusion because people may voluntarily exclude themselves from the financial services for religious or cultural reasons, even though they do have access and can afford the services (Beck & Dermiguc-Kunt 2008). This type of study of financial exclusion is often relates to ethnicity as ethnicity itself is believed to be a major reason for financial exclusion in some developed countries. For instance in the UK those who were classified as ethnic Muslims are many times more likely to be financially excluded than their counterparts in the same category. It was

reported that being Pakistani makes someone four times as likely to be without a bank account while being Bangladeshi triples the odds (Kempson 2001).

It is general consensus among many commentators on the subject of faith-related financial exclusion that the lack of *Shariah*-compliant products is the major reason behind the wide financial exclusion which exists among various Muslim communities in many parts of the world (Mohieldin 2011; Pearce 2010). This refers to financial products and services that comply with the principles of Islamic law (*Shariah*) as Muslims are prohibited from accessing any finance involving the payment and receipt of interest (*Riba*). One of the *Shariah* scholars advising Lloyds TSB told the BBC in June 2006: "Access to *Shariah* compliant financial products would ultimately mean "less exclusion and less extremism" (Knight 2006).

He was also quoted as saying:

> "Everyone needs financial services. We should see less and less exclusion and less extremism. The spread of Islamic financial services would help combat social and financial exclusion amongst the UK's 1.6 million Muslims" (Knight 2006).

As the above literature suggests a major portion of the financial exclusion among Muslims in countries where Islamic financial services and products are in short supply could be linked to religiosity. Although faith-related financial exclusion deters many social groups and individuals from accessing certain financial products, the causes of the problem are wider and more diverse. Generally, the causes of financial exclusion are many and varied but a general tendency can still be detected. Indeed, and not so surprisingly, the most frequently evoked causes are as follows:

Societal Factors

Societal factors play an important role in the financial exclusion of certain social groups and individual (Aalbers 2011). For example, liberalisation of financial markets has led to the creation of more sophisticated and varied financial products. It has increased the financial inclusion of the well of but having an adverse effect for the lower income group who are still trapped in their vicious cycle of social deprivation and poverty. On the other hand, when rules on financial transactions have become tighter to combat financial crimes, such as money laundering, it significantly bars certain group of people from accessing certain financial services and products in some countries (Burgstaller 2013). Similarly, the vast changes in technological advancement has leads to some sort of financial exclusion as the older generation find it difficult to cope with the higher dependency on technology where most of the traditional banking services have been taken over by modern technology, such as internet and phone banking (Anderloni et al. 2006; Atkinson 2006; Kempson 2001). 'Self-exclusion' is another key societal factor that substantially increased financial exclusion. This refers to cultural and psychological barriers to financial services when the less well-off group or individual feels that financial services are "not for people like us" (Collard et al. 2001; Kempson 2001; Mitton 2008). Some commentators opined that a major portion of this type of financial exclusion is fuelled by religious and cultural motives and is recognised across the board as one of the most difficult and prevalent deterrents holding back the unbanked communities (Buckland 2003; Mcdonnell & Westbury 2002). They believe that the indigenous populations of Australia and Canada are prevented from using banking services due to psychological and cultural barriers. Similarly, the Pakistani and Bangladeshi Muslim communities in Britain are excluded from banking as transactions

can cause them to become inadvertently overdrawn and thus incurring interest, which is forbidden (*haram)* under *Shariah law* (Collard et al. 2001).

Supply Factors

Based on literature under review, it is noted that most of the previous study on financial exclusion, focused only on the supply factors as they are the most obvious and common reasons for this problem (Kempson et al. 2004; Saunders 2011). This occurs as a result of the financial institution's failure and/or hesitance to offer the suitable and affordable financial products to the less well-off, whose financial services needs are quite different from the needs of their counterpart. Bank refusals, identity requirements, unfavourable terms and conditions, bank charges, geographical remoteness and technological advancements are some of the major ingredients of the supply factors of financial exclusion. However, the supply factors can be generally grouped as follows:

1. Access exclusion which refers to access barriers such as geographical and physical exclusion of people living in disadvantaged neighbourhoods (Alamá & Tortosa-Ausina 2012; Collard et al. 2001; Kempson 2001).
2. Condition exclusion which refers to being excluded due to certain conditions such as failing to pay the minimum deposit required for opening certain accounts, failed certain conditions such as credit history checks and required income threshold due to their low income, as banks perceive them to be high-risk and unworthy customers (Howell & Wilson 2005). Identity requirements may also affect certain groups such as the homeless and refugees who normally cannot provide the required identity for account-opening purposes (Datta 2009).
3. In another context, price exclusion such as bank charges act as a deterrent when people on low incomes are required to pay charges they cannot afford (Burkett & Sheehan 2009).

Demand Factors

Demand factors refer to the cultural and psychological factors that deter some people from accessing financial products. For instance, less educated people feel that banks are not for them and therefore they mistrust them and seek other means of handling their finances (Anderloni 2008; Barry 1998). Also, elderly people generally feel uncomfortable using modern technology, such as the internet, and prefer traditional ways of managing their finances. Some are worried about losing their money should the bank go bankrupt as witnessed in some parts of the world, including some Western countries (Wilson 2006). Apart from the elderly people, the middle aged group of people are also concerned about employing modern technology to manage their finances, such as internet banking, due to the fear of financial loss through on-line identity theft or some other type of fraud such as internet hacking. This is a justifiable concern for many and is thought to be one of the demand-related factors that stop people from demanding certain financial products and services (Mitton 2008; Osei-Assibey 2010).

Marketing strategies employed by banks and other financial institutions (FI) may also exclude certain sector of the population from demanding financial products. Most of the commercial publicity was designed to cater for the affluent group of people,

which drives the opposite group away as they feel alienated and excluded by these adverts and look for alternative means of managing their finances (Anderloni et al. 2006; Healey 2011). Premised on the above, societal, supply and demand factors can play a role in the exclusion or limited inclusion of individuals. In summary, the above three factors are the most common causes of financial exclusion but availability of financial products and services may not equal financial inclusion, because people may voluntarily exclude themselves from the financial services for religious or cultural reasons, even though they do have access and can afford the services (Beck & Dermiguc-Kunt 2008).

MUSLIMS IN AUSTRALIA

Muslims in Australia is a minority religious group. According to Census 2011, 476,300 people or 2.25% of the total Australian population were Muslims. This made Islam the fourth largest religious grouping, after all forms of Christianity (64%), no religion (22.9%) and Buddhism (2.5%) (ABS 2011). The Australian Muslim community is drawn from more than 70 different countries, is ethnically and linguistically diverse, and geographically scattered (DFAT, 2008). There are indications that even earlier Muslim Arab explorations took place off northern Australia. The map of the Sea of Java of Muhammad ibn Musa al-Khwarizmi 820 CE shows, Cape York Peninsular, a "V" shaped Gulf of Carpentaria and a curved Arnhem Land. A later map by Abu Isak Al-Farisi Istakhari 934 CE, also includes an outline of the northern coast of Australia (Tames 1999). The first regular Muslim contacts with Australia were made by the people of Makassar from Indonesia who had converted to Islam in the early 1600s. They traded with the Aboriginal people living along the northern coast from about 1650 until the early 1900s and influenced their language and culture. A few Muslim free settlers and some Muslim sailors arrived in the early years of settlement but little is known of them. The most significant early arrivals were the 'Afghan' cameleers who from 1860 to 1939 took part in expeditions to explore the interior. They were also involved in survey, construction and carrier work for the Overland Telegraph Line from 1870 to 1872, supplied the goldfields and provided an essential transport and communications network throughout Australia until they were superseded by rail, road and air services (Tames 1999).

It is the teaching of Islam that Muslims are forbade from dealing with *Riba* or well known as usury and/or interest which is widely being practise in the conventional banking and finance systems. In a policy research working paper (PWS6290) published by The World Bank in December 2012, 5 per cent of the of the respondents from 123 countries do not have a formal account with a financial institution because of their religious belief (Allen et al. 2012). Based on literature, Muslims are particularly excluded from the main conventional banking and financial products such as mortgages, personal, business and investment accounts due to the prohibition of *Riba.* The provision of these services in a manner compliant with their faith would be welcomed by this community provided it is deemed that the products offered are authentic, competitive and relevant to the consumers' requirements.

RESEARCH METHODOLOGY

The design of the study would be using qualitative and quantitative method or more commonly known as mixed methods. The assumption of this study is that different data

offer useful insights for understanding financial exclusion. Based on literature available, research can take the form of three basic designs that is exploratory, descriptive or causal (Leedy & Ormrod 2009). The focus of this study will be an exploratory in nature and the sample survey method (questionnaire) would be one of the appropriate methods for data collection. Under this method the data is collected from a portion of the populations and from that data appropriate inferences about the population can be made. Even though this means that the sample serves only as an approximation of the entire population, it has been recommended as it could actually be highly accurate if chosen with care (Cresswell 2007). In another context, semi-structured interviews are usually used to find answers from the respondents to specific questions. In this research, practitioners and scholars of Islamic finance will be interviewed with the objective of gaining answers for the research question. Generally, a combination of two or more research methods will give better interpretation as the information missed by one method may be captured in another method (Creswell 2009).

INITIAL FINDINGS

As mentioned earlier, the study is in the process of data collection and the finding here are not supported by any empirical work but based entirely on secondary data. An in-depth examination of issues was not undertaken and the scope of the paper was limited to existing materials. In 2012, more than three million Australians suffer severe or full financial exclusion. In real terms, 194,117 adults are fully excluded and 2,929,402 are severely excluded providing a combined total of 3,123,519 (Connoly 2013). This was based on the research conducted by the National Australia Bank (NAB) and the Centre for Social Impact (CSI). The measurement of financial exclusion employed in NAB/CSI report are based on the ability to access three basic financial tools i.e. a basic transaction account, moderate amount of credit and general insurance, with severe exclusions being an inability to access any two of three tools and full exclusion being the inability to access any of them. Summary of three years statistical data of Australian adult populations that were fully and severely excluded is shown in Table 1 below:

Table 1. Data of Australian adult populations that were fully and severely excluded from 2010 to 2012 (Connolly et al. 2012; Connolly et al. 2011; Connoly 2013).

Degree of Exclusion	2010	2011	2012
Fully excluded	129,000	192,000	194,117
Severely excluded	2,521,000	2,803,000	2,929,402
Total	2,650,000	2,995,000	3,123,519

The research showed the cost of maintaining basic financial services has fallen from previous years, with the average costs at $1739 per year. CSI Research Associate Chris Connolly said cost had to be considered alongside other barriers, such as difficulties with language and identification documents, a general lack of financial literacy and changes in employment arrangements, which all contributed to the growth in financial exclusion.

> "Younger Australians and migrants are particularly marginalised. The casualization of our workforce is compounding the issue, with increasing

numbers of people engaged in low-paying casual, part-time or seasonal work," Connolly said (Spits 2013).

According to the research, young adults aged 18-24, migrants and people engaged in low-paying casual, part-time and seasonal work are the most excluded, as are many Aboriginal and Torres Straight Islanders. The research shows 43.1 per cent of the latter group suffer some form of exclusion. The costs and complexity of insurance products also keep people with low incomes from accessing appropriate insurance. A geographical breakdown highlighted that areas with low levels of insurance were usually inner-city areas of the large capital cities or extremely remote areas. The NAB/CSI Financial Exclusion Indicator research was drawn from face-to-face interviews with 50,000 Australians, and additional online surveys of a further 1500 people. The historical data of financial exclusion in Australia from 2007 to 2012 (adopted from Connolly 2013) are summarized in Table 2 below:

Table 2: extent of financial exclusion in Australia 2007– 2012

Degree of Exclusion	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Included	45.7%	46.6%	44.6%	43.4%	40.8%	39.7%
Marginally excluded	38.4%	38.7%	40.0%	41.0%	42.0%	42.6%
Severely excluded	14.5%	13.8%	14.6%	14.8%	16.1%	16.6%
Fully excluded	1.5%	0.9%	0.7%	0.8%	1.1%	1.1%

As this study was about financial exclusion faced by the Muslim community in Australia which is also in relation to exclusion due to faith and religious belief, the study found that Islamic finance facilities (*Shariah*-compliant) are not being widely offered in Australia. There are 20 locally owned banks, 8 foreign subsidiary banks and 40 branches of foreign banks in Australia (APRA 2013). However, none of these banks or any of the high street banks offered Islamic banking and finance facilities even though some of the foreign banks do provide it outside Australia. The Islamic banking and finance facilities referred here includes savings and current account, credit card and mortgages/financing (i.e. home or vehicle). Australia's experience with Islamic financing has been relatively new. The first attempt to introduce Islamic financing products in Australia was made by the Muslim Community Co-operative Australia (MCCA) (Ahmad et al. 2010). The organization began in 1989 with AU$22,300 worth of seeding capital and by 2003 MCCA had 5,600 members and deposits worth AU$24 million (Faruq & Rafique 2009). Majority of the MCCA members are from Melbourne and Sydney where the organization has a physical presence. The products and services offered by MCCA ranges from investments to home financing (MCCA 2013).

Apart from MCCA, there are another two organisations that offer Islamic finance facilities: Islamic Co-operative Finance Australia Limited (ICFAL) and Iskan Finance (ISKAN). ICFAL provide home and vehicle financing to its members only and they are operating in Sydney (ICFAL 2013). Meanwhile, ISKAN solely offering home financing facility and it is open to the public i.e. Muslim and Non-Muslim and their operations are centralised in Sydney (ISKAN 2013). In terms of Islamic fund management, there is Crescent Wealth, a wealth management company offering a

superannuation fund as well as a series of managed funds that invest into socially responsible assets based on Islamic investment principles (CrescentWealth 2013). The expansion and growth of Islamic finance in Australia has been slow due to various reasons, for example lack of regulatory support and policy framework (Ahmad et al. 2010). Further discussion on the development and impediment of Islamic finance in Australia are discussed in the author's paper titled "Islamic Finance in Australia: History and Development" (Sain et al. 2013).

In summary, if we based on NAB/CSI's financial exclusion measurement criteria (access to three basic financial tools i.e. a basic transaction account, moderate amount of credit or general insurance), it appears that only one financial tool that is available in the Australian market which comply with Islamic law (*Shariah*): moderate amount of credit. The example of access to moderate amount of credit is through *Qard Hassan* or No Interest loan offered by The Islamic Council of Victoria (ICV 2013). The scheme of *Qard Hassan* provides loans of up to $1000 to people on low incomes for the purchase of essential household items that will improve the quality of their life. For the purpose of understanding, Qard Hassan means gratuitous or beneficial loan which is a loan given to a borrower without charging interest as payment and receipt of interest is prohibited in Islam. In fact it is the only type of loan acceptable in Islam and it is sometimes referred to as "benevolent loan". For home and vehicle financing, MCCA, ICFAL and ISKAN do offer such facilities but it must be mention here that the availability are subject to limitation of area because these companies are mainly operating in Sydney and Melbourne. Meanwhile, the other two financial tools i.e. basic transaction account and general insurance that are *Shariah*-compliant are not available.

CONCLUSIONS

This paper concludes that financial exclusion is a process whereby people encounter difficulties accessing and/or using financial services and products in the mainstream financial system that are in accordance to their needs and requirements. Societal, supply and demand factors remained to be the three common causes of financial exclusion. Tackling financial exclusion is important because it is not just about increasing access to financial systems, but it goes beyond that boundary. If we analyse carefully, it actually helps to fight poverty and improving the economic status of the people and/or the community. Hence, by tackling financial exclusion problems it will indirectly addressed the social related issues. Nevertheless, this paper also found that there is still lacking of information about financial exclusion according to ethnicity or religious group in Australia. As such, there is still plenty of room for in depth study on the subject of financial exclusion in Australia. On another context, it appears that Islamic finance facilities currently being offered in Australia are still limited in terms of its availability and range of products and services. We fear that these limitations will exclude a proportionate population in Australia i.e. the Muslim community from being involved in a wider financial activities because to them, conventional banking and finance is not acceptable based on *Shariah* principles. This is because conventional banking and finance contains *haram* (prohibited) elements such as *riba* (interest), *gharar* (uncertain factors) and *maysir* (gambling). Hence, the financial sector will not achieve its optimal outcomes keeping the Muslim community, out of the financial market.

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FACTORS INFLUENCING THE ADOPTION OF CLOUD COMPUTING: A REVIEW OF LITERATURE

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ABSTRACT

Cloud computing reflect a new way in consuming and using IT infrastructures and IT resources. When adopting cloud computing, users are required to dismantle their current technologies, transferring the control of their IT infrastructures and data over to third party (cloud service providers). This is a distinctive departure from other information systems (IS) and information technology (IT) that has penetrated the market to date. This study reviewed and synthesizes the view of past literatures on cloud computing adoption, and suggests critical factors that need to be properly addressed by the adopting organizations leading to successful embracement of the cloud technologies. Consequently, a conceptual framework is proposed. The framework is demonstratively derived from the reviewed literature and has the potential to shed new light in the current state of knowledge on cloud computing adoption and implementation.

Keywords: Cloud computing, cloud computing adoption and implementation.

INTRODUCTION

Cloud computing reflect a new way in consuming and using information technology (IT) infrastructures and resources. Furthermore, migration to cloud computing signifies a strategic choice of competitive advantage for companies (Kuyucu, 2011). Cloud computing provides adopting organizations with convenience and quality-stable technological support and the opportunity of flexibility and adaptability to attract market on demand (Buyya et al., 2009; Low, Chen and Wu 2011; Pyke 2009). Nonetheless, the limitations and risks encountered when utilizing or integrating cloud technology into existing IT environment have been described as significant (Velev and Zlateva, 2011), posing great challenges to organizations intending to gain competitive advantage in their investments in cloud technology. As new technologies emerged, researchers (Armbrust et al., 2010; Goscinski, 2010) posited that it is crucial to understand the factors leading to its adoption.

The existing literature primarily focused on the fundamental and technical aspects of cloud computing concepts (Armbrust et al., 2009; Karabek, Kleinert and Pohl, 2011; Mell & Grance, 2011; NIST, 2011; Vaquero et al., 2008), with only a handful number of empirical research investigating the adoption and implementation issues of cloud computing (Low, Chen and Wu, 2011; Yinglei and Lei, 2011). Cloud computing has been referred to as a 'game-changer' (Fershtman and Gandal, 2012), that

will inevitably change the IT industry, yet there is virtually no research on the economics of it. Hence, this study seeks to contribute to the body of literature by proposing a conceptual framework of the factors perceived to influence the adoption of cloud computing technologies. We hoped that this study will shed new light on the current state of knowledge on IS and IT adoption particularly on the adoption of cloud computing technology. As such, it is essential to start this study with a clear conceptualisation of cloud computing adoption. This leads to the overarching research question of this study: ***What is the factors influencing the adoption of cloud computing?***

RESEARCH METHOD

A literature review approach provides researchers the grounds to conceptualize research areas and synthesize prior research (Webster and Watson, 2002). A number of researchers (Yang and Tate, 2009; Levy and Ellis, 2006; King and He, 2005) acknowledged this method as one of the ways to review emerging trends and identify the patterns of the surveyed papers, which contribute to a cumulative culture involving a systematic review of searching, filtering and classifying processes. Ultimately, the intended outcome of the review presents the state of art of the research domain acceptable by many researchers (Yang and Tate, 2009). Building on the above concept, this study aims to synthesize the views of past literatures on cloud computing adoption spanning from a period of the last ten years (2002 – 2012) by demonstrating the critical factors in a conceptual framework.

LITERATURE REVIEW

Cloud computing entails a paradigm shift from in-house processing and storage of data to a model where data travels over the Internet to and from one or more externally located and managed data centers (Trappler, 2012). Cloud computing has changed the existing IT ecosystem, by providing IT infrastructures and IT resources as standardized and virtualized cloud services via the Internet (Karabek, Kleinert and Pohl, 2011). The adoption of cloud computing requires adopting organizations to dismantle their current technologies, thus, transferring the control of their IT resources and data over to third party (cloud service providers). This is a distinctive departure from other information systems (IS) and IT that has penetrated the market to date. In general, this paper attempts to define the specific issues associated with cloud computing adoption and to draw some analogies to cloud computing stakeholders. A recent study done by Low, Chen and Wu (2011) discussed the determinants of cloud computing adoption. Nonetheless, this study only discovers the positive or negative association of the variables (Technology, Organization and Environment) in cloud computing adoption. Our study extended the work of Low et al. (2011) by examining the internal and external contexts of cloud computing adoption incorporating perceived values (economic, technology and resource) and attempt to discover how cloud computing unique characteristics influence its adoption.

Alike other IT deployment that has dominated the industry, potential adopters must be wary on the challenges faced when migrating to the cloud environment. Expenditures in new technologies, without a solid understanding of what factors influence their decision to adopt, can lead to loss of time and project delays (McCracken 2011). In line with that, researchers (Low, Chen and Wu, 2011) coined that in order to

promote cloud computing adoption, it is necessary to clarify the factors that lead to its' adoption. Others (Flick, 2009; Lease, 2005) on the other hand, argued that a decision to recommend a new technology may be based on evaluating capabilities, features, and challenges of the technology. Nonetheless, researchers (Chow et al., 2009) argued that many adoption issues of cloud computing are essentially old problems in a new settings. As such, despite the obvious cloud computing advantages both strategically and operationally, IT professionals are still reticent about adopting the emerging cloud computing technologies (Buyya et al., 2009; Goscinski and Brock, 2010; Low, Chen and Wu, 2011).

Conceptual framework

The adoption of complex IT innovations requires advantageous technology portfolio, organisational structure, and environmental strategy (Swanson, 1995). Hence, the conceptual framework of this study were demonstratively derived from IS/IT adoption theories specifically the Technology Organization and Environment (TOE) developed by Tornatzky and Klein (1990) and value creation theory of resource based view (RBV). Borrowing the constructs from those theories, the conceptual framework posits that the adoption of cloud computing were influence by a firm's internal and external factors, hence, affecting the firm's organizational and operational performance. This study adopt technological and organizational factors as internal factors affecting cloud computing adoption, which are expected to posed certain challenges and add values to the adopting organizations.

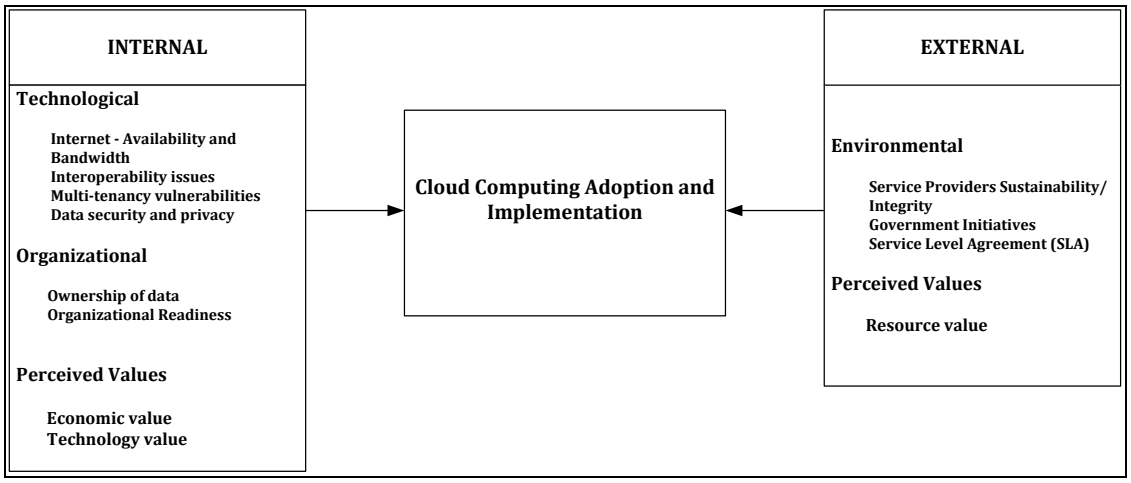

Figure 1. Conceptual framework

Studies done by researchers (Low, Chen and Wu, 2011) reported that external characteristics such as environmental factors have either a positive or negative impact on cloud computing adoption. This study identified these positive impacts as values created and negative impacts as challenges faced by adopting organization concerning the external environment. The framework also incorporates key characteristics; service level agreement (SLA) and cloud service provider's sustainability and integrity as the key enabler of successful adoption of cloud computing technologies. The Figure 1 depicts factors identified by the literature as challenges or values of the cloud technology. Researcher (Rogers, 1995) posited that an individual or organizations may

adopt or reject a new innovations based on the characteristics of such innovation. Conceptualization and a literature review for each of the above constructs are presented below.

Perceived internal factors influencing cloud computing adoption

Technological factors

Cloud computing comes with its own unique set of challenges (Trappler, 2012). Data security and privacy issues has been highly anticipated by most researchers as the main concern that may posed great challenge to cloud adopters (Ahmad, 2010; Babu et al., 2011; Buyya et al., 2009; Dillon, Chen and Chang, 2010; Kaur and Kaushal, 2011; NIST, 2011; Raj & Periasamy, 2011; Sharma, Sood and Kaur 2011; Vaquero and Morán, 2011; Velev and Zlateva, 2011; Zissis and Lekkas, 2012). A survey done by Forrester Research, further contend that enterprises require substantial guarantees for data protection before moving to the cloud environment (Karabek, Kleinert and Pohl, 2011). Furthermore, confusion arises on the location of the data (Velev and Zlateva, 2011), issues of data privacy (Ahmad, 2010) and security policies (Lyong, 2011). The degree to which cloud technologies is compatible to existing IT resources within the adopter's organization is also highly uncertain. Hence, researchers asserted factors such as internet availability (Castellina, 2011; Lenart, 2011; Low, Chen and Wu, 2011; Wu, Lan and Lee, 2011), interoperability and portability (Hofmann and Woods, 2010; Kim et al., 2009; Mäkilä et al., 2010; NIST, 2011; Sharma et al., 2010), multi-tenancy or shared technology vulnerabilities (Chow et al., 2009; Rittinghouse and Ransome, 2010; Vaquero et al., 2008; Velev and Zlateva, 2011), integration with in-house IT and the difficulty of customization (Ellis, 2010), as factors that could cause major disruptions to cloud computing adoption and should be properly addressed by potential cloud users when embracing the cloud technology.

Although researchers were keen to discuss the issues pertaining to cloud computing adoption in respects of its challenges but our reviewed literature found quite a number of studies exploring the positive impacts of cloud computing in terms of the values created by the cloud technology. The most prominent technological values discovered from the literatures were scalability and on demand (Castellina, 2011; Lenart, 2011; OECD, 2010; Wu, 2011). Scalability enables cloud adopters to quickly scale capacity without human intervention and increased mobility of cloud users as data can be accessed at any location as long as there is internet connection. Apart from that cloud technology offers flexibility to cloud adopters to expand their businesses to reach a wider group of customers (Saeed et al., 2011). Moreover, since the cloud technology is managed and maintained by cloud service providers, immediate upgrading ensures access to the most up-to-date solutions (Castellina, 2011; Chandrasekaran and Kapoor, 2011; Chunlan and Zhonghua, 2011).

Organizational factors

Potential cloud adopters must be wary of the trade-off between anticipated cost savings and the convenience and comfort of local deployment, control and operation (Erdogmus, 2009). Similar to other IS and IT, cloud computing posed challenges in terms of organizational context. Furthermore, ownership of data residing in the cloud posed negative concerns on the adopting organizations (Gartner, 2008). Cloud

computing for instance, may fail to give customer greater sense of ownership as they neither own the infrastructure nor run the applications (Trappler, 2012). Unfortunately, a rapid deployment of functionality does not necessarily means a rapid user acceptance and effective use of technology (Beaubouef, 2011). As such, IT and employee readiness concerning the use this technology needs to be addressed (Beaubouef, 2011).

Economical factors

The main contribution of the cloud model is said to be on the economics and simplification of software delivery and operation (Erdogmus, (2009). A number of researchers (Beaubouef, 2011; Castellina, 2011; Lenart, 2011; Saeed, Juell-Skielse and Uppström, 2011; Saini et al., 2011; Chandrasekaran and Kapoor, 2011) realised reduction in IT investments as the greatest advantage that cloud computing offers. Furthermore the cloud's pay-per-use concepts allowed users to pay for only what they use and thus, promotes cost savings (Ververka, 2010). Small businesses with no initial outlay on IT infrastructures and IT resources is said to be more attracted to cloud computing as it is more cost effective (Beaubouef, 2011). Some researcher (Wu, 2011; Chandrasekaran and Kapoor, 2011) further proposed that IT costs become a variable operational expense for cloud users because the capacity is shared.

Another key advantage is the elimination of monitoring and managing IT resources (Castellina, 2011; Lenart, 2011), which reduce the workload of IT staff (Chandrasekaran and Kapoor, 2011) and allows organisation to focus more on their strategic activities while leaving the non-strategic activity to the cloud vendor (Beaubouef, 2011; Castellina, 2011; Epicor ; Saeed, Juell-Skielse and Uppström, 2011). In addition the cloud technologies enables business agility by eliminating time consuming activities and IT resources are provision instantly (Chandrasekaran and Kapoor, 2011). This has also enabled businesses to immediately respond to business requirements (Wu, 2011) and thus fulfilling customers demand. Cloud computing also shifts the IT burden and associated risks to the vendor, who can spread variations over many customers (Hofmann and Woods, 2010). Strategically, cloud technologies presents new business opportunities to businesses of all sizes to develop new products and services (Kshetri, 2010), hence a new set of market share is develop based on cloud computing.

Perceived external factors influencing cloud computing adoption

The development of cloud computing is said to be at its' infant stage (Mikkilineni and Sarathy, 2009). Since the technology is being provisioned by cloud service providers, the possibility that business operations may be disrupted if cloud service providers failed to provide the promised services arise the issue of longevity of cloud services. The reviewed literatures revealed the following factors that may influence cloud computing adoption.

Environmental factors

A number of researchers recognized the importance of a comprehensive service level agreement (SLA) (Fawaz et al., 2004; Jin, Machiraju and Sahai, 2002; Rouse, 2005; Gartner, 2008; Trappler, 2012) binding the cloud service providers with cloud adopters. The SLA must specify detailed technical specifications of what types of services being

provisioned and how it should be provided. Furthermore the above researchers highly recommend that potential cloud adopters to scrutinize the following aspects: parameters and minimum levels for each element of the service provided and remedies that apply when they are not met; ownership of data stored on service provider's system and your rights to get it back; details the system infrastructure and security standards to be maintained by service providers along with your rights to audit their compliance; and specifies your right and cost to continue and discontinue using the service. The complexity of the cloud computing environment demands that organizations be extremely diligent in negotiating contracts for cloud computing (Trappler, 2012). Nonetheless, the sustainability and integrity of cloud service providers in continuously provisioning the cloud service posed as a major setback that may result in disruption in cloud users' business operations (Erdogmus, 2009). Therefore, a separate management of application availability, performance optimization, and security is required to facilitate the cloud on demand characteristics (Erdogmus, 2009).

Resource factors

Cloud computing undoubtedly offers cloud service providers utilization of their IT capabilities (Brynjolfsson, Hofmann and Jordan, 2010), and allows cloud users to access a large pool of resources (Chandrasekaran and Kapoor, 2011; Chunlan and Zhonghua, 2011) that is relevant to their business operations (Sharif, 2010; Chunlan and Zhonghua, 2011), and with less energy consume (Bajenaru, 2010; Beaubouef, 2011). The following Table 1 summarizes the factors influencing cloud computing adoption.

Table 1. Factors influencing the adoption of cloud computing

Factors Influencing Cloud Computing Adoption		Perceived challenges	Perceived values	Authors
Internal factors	Technological	Security and privacy Internet availability and bandwidth Complexity of Interoperability Multi-tenancy vulnerabilities	Scalability On-demand Flexibility – business innovation Up-to-date IT resources Immediate upgrading	Low et al. 2011, Karabek et. al.2011, Trappler, 2012; IDC 2010; Chandrasekaran & Kapoor 2011; Kshetri 2010 ; Beaubeouf 2011; Munteanu & Fotache 2010; Lenart 2011; Castellina 2011; OECD 2010
	Organizational	Ownership Of Data Organizational Readiness		Castellina 2011, Lenart 2011, Wu et al. 2011, Velev & Zlateva 2011, Trappler 2012, Beaubouef 2011
	Economical		Reduction in IT investments Cost savings Pay-per-use Increased productivity	Lenart 2011; Castellina 2011; Chandrasekaran & Kapoor 2011; Beaubeouf 2011
External factors	Environmental	Service Level Agreements (SLA) Sustainability/Integrity of Cloud Service Providers		MDeC 2011, Fawaz et al. 2004, Rouse 2005, Trappler 2012, Jin et al. 2002, Rosenbaum & Bruce 2010
	Resources	Utilization of IT resources Central pool of shared resources Utility model		Chandrasekaran & Kapoor 2011; Beaubeouf 2011; Kshetri 2010 ; Chunlan & Zhonghua 2011

CONCLUSION

Technically loud computing is simple to deploy, and it represents the latest, greatest, and most influential IT change in years (Mozammel-Bin-Motalab and Shohag, 2011). It represent a fundamental shift in the way IT services are developed, deployed, scaled, updated, maintained and paid for (Marston et al., 2010). In summary, this paper presents a pragmatic understanding of the factors influencing the adoption and implementation of cloud computing. Since this is a research in progress, the next phase is to investigate the process modification introduced by the cloud technology that may affect the organizational dynamics and operational performance of the adopting organizations. Furthermore future research on how organizations managed the change from an internally control IT resources and infrastructures to an externally (cloud service provides) and the way cloud computing implementation had occurred in terms of the speed the sequence of activities, business processes and operation changes, resistance encountered, resources redeployed, and the implementation strategies is another area worth investigating.

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WATER LOSS AND FLOW CHARACTERISTICS OF UITM SHAH ALAM WATER SUPPLY SYSTEM THROUGH HYDRAULIC SIMULATIONS

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ABSTRACT

Water loss control is a very crucial part in practising good water management. It can happen in many ways. However, not all losses can be avoidable and became a matter especially when the lost water has no value. To study about water loss, site-specific analysis should be done to get level of water losses. This study discusses possibility of water losses conjunction with pressure management based on current situation or practice in Universiti Teknologi MARA, Shah Alam, Selangor. It explores the amount of water loss by comparing between current bills and the theoretical calculation based on number of consumer in the area. Due to the social, economic and environment change, pressure management remain a challenge. Knowing the weakest pressure that can occur in the water distribution system can help engineers take appropriate action immediately. There are a lot of techniques to check water pressure level. In this study EPANET 2 was used to perform extended period simulation of hydraulic and water quality behaviour within pressurized pipe networks. The programme analyses the pressure at each node, track the flow of water in each pipe and height of the water in each tank during simulation period. After the whole system is simulated, results were presented in various form of analysis and compared with the real-time measured data. Water loss in study area is slightly insignificant because of the small differences between actual and theoretical values. Therefore, it can be assume that pipe network in the study area is in stable operating system even though some of the pipe is in old age.

Keywords: Water loss, hydraulic simulation, water pressure, velocity distribution

INTRODUCTION

Water supply in Malaysia mainly comes from river and stream. In 1980s, the demand for water supply was grown rapidly especially in residential and industrial sector. This water is distributed to consumer by proper design reticulation system. Water distribution system involves interconnection between pipes, sources and hydraulic control element such as pumps, valves, regulators and tanks. A normal concept of water distribution is to deliver water to consumers based on demand quantities and desired pressures (Ostfeld *et al.,* 2001). Non revenue water is the difference between net production of water into the water distribution system and the amount of water that is billed. This is the major problems accounted by the water utility provider worldwide. The water losses can be cause by apparent losses such as meter inaccuracies or real losses for example through pipe burst due to high pressure. However, the economic effect through loss of water is not only the concern of the water provider but also the consumers who have to pay more than what is actually being utilised. Hence, a strategic water management to improve water loss through proper pressure management can be adopted since it will

not only provide a financial gain but also help in saving precious water for a sustainable environment. The aims of this study are to identify water loss in piping network system from water tank to the supplies area and to carry out hydraulic modelling analysis and determine water pressure and velocity trend to control water loss problem.

OVERVIEW ON NON-REVENUE WATER

Ruhana *et al. (*2007), interpreted non-revenue water (NRW) as a water loss from the many public water utilities due to poor water distribution network facilities and management, the losses may cause by corrosive environments, soil movement, poor construction standards, fluctuation of water pressure, and excessive traffic loads and vibration. Due to these causes, water loss could occur at different components such as transmission pipes, distribution pipes, service connection pipes, joints, valves, fire hydrants, and storage tanks and reservoirs. Water loss through leakage can be minimized by a proper pressure management. As stated by Clarke (2005) if there is a leaking garden hose that has a pressure of 60 psi (4 Bar) and then the pressure being reduce to 30 psi (2 Bar), there will be less water loss through that leak. The same principle holds true in a water utility's distribution system. It is a well-known fact that with decrease pressure within the system, it will also reduce water loss. By reducing pressure by 1%, leakage will be reduced by 1.15% (variances can apply). The question is by how much pressure can be reduced while maintaining adequate pressure to the customers. The resulting water loss savings relating to main and service lines can be incredible in both volume and cost. Lalonde *et al*. (2007) had also previously carried out a study on pressure management as an important measure for the long term reduction of real losses in the City of Toronto. The study highlighted the principle behind pressure management is quite simple – lower system pressures during periods of lower demands (when system pressures normally rise) and reduce the flow rate from existing background leakage (those small weeping leaks from fittings and joints). An additional benefit of pressure management is the related reduction in water main break frequencies which in turn help to extend the life of the underground infrastructure. Yate's (2007) explanation to be considered successful; reductions in real losses through advanced pressure management had to be achieved without degrading minimum system requirements. Adequate minimum residual pressures had to be maintained during peak hourly flow or maximum day demand plus fire flows.

Hydraulic Simulation

Hydraulic simulation models are becoming of common use among planners, water utility personnel, consultants and many others involved in analysis, design, operation or maintenance of water distribution systems. In order to make network simulation models useful, it is necessary to calibrate them before being used (Walski, 1983) The model calibration process consists of adjusting a set of physical and operational parameters for the purpose of achieving a reasonable match between measured and computed pressures and flows in the network. A water distribution model, in order to be reliable, must be calibrated, that is, the model must be capable of accurately predicting flow and pressure conditions at any point of the system. Various parameters should be used as an input to the hydraulic simulation model to provide reasonable match between measured and predicted pressures and flow in the existing water network system (Bartolin & Martinez, 2001). EPANET is a computer program that performs extended period simulation of

hydraulic and water quality behaviour within pressurized pipe networks. It is designed to be a research tool which can be used for many different kinds of applications in distribution systems analysis such as sampling program design and hydraulic model calibration. EPANET tracks the flow of water in each pipe, the pressure at each node and the height of water in each tank throughout the network during a simulation period comprised of multiple time steps (Mamdouh, 2010).

METHODOLOGY

This study outlines the importance of proactive pressure management as part of a strategy for effective management of real water losses. Specific area was chosen which started from water tank 3 located near UiTM entrance gate 2 and this tank supplies water mostly to Mawar and Melati College area. The reason of choosing this area is due to high water demand from the college area especially at the beginning of semester. Based on the population of consumer, these two colleges were identified having highest number of resident compared to other colleges in UiTM Shah Alam campus. Figure 1 shows the percentage of resident in all colleges in UiTM Shah Alam. Mawar and Melati colleges record highest percentage of resident's number with 17% which is about 3500 capacity of residents each.

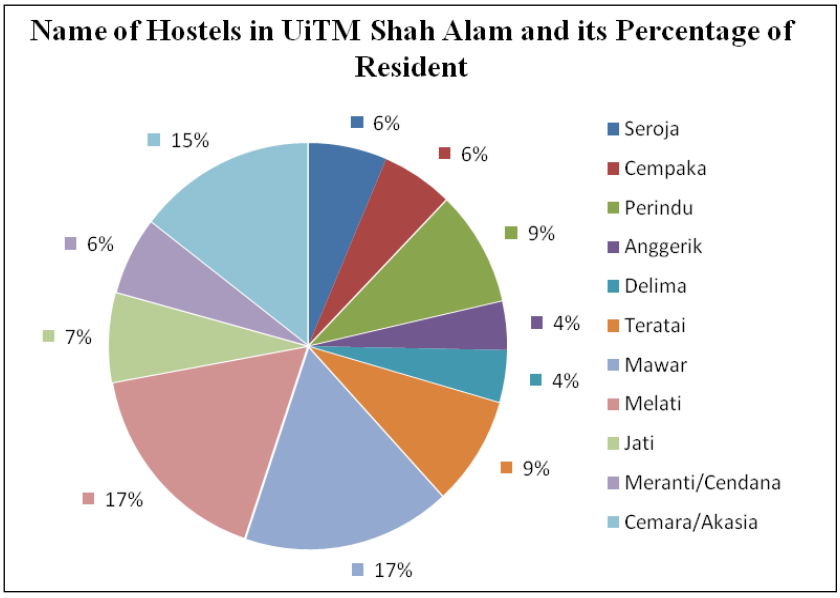

Figure 1. Percentage of residents for 11 colleges in UiTM Shah Alam administration.

Based on this population percentage, the water usage in these areas is identified running high because of the activities running in the building such as washing, bathing, cleaning and etc. Software EPANET was used to analyse the piping system. From this software the trend of flow velocity and pressure can be predicted based on the parameter setting over an extended period of time. Therefore pressure analysing was identified to see whether it is enough to supply water to consumer. After the simulation the result are shown in various format and comparison with current data was done.

Demand Calculation

Water demand in a realistic condition for a supply system is always less than the total theoretical demand. However, it should be noted that the minimum expected total water flow can never be less than the demand from largest fixture. The formula to calculate water demand is as follow:

Water Demand (L/d) = Population (Person) x per capita Consumption (L/person/d)

The value of population or person by per consumption is different for each type of place (e.g. home, office, library, etc.) and group size (e.g. hostel, hospital, school, etc.).

Table 1. Rate of Demand in Mawar and Melati College, UiTM Shah Alam

No	Name of Hostel	Max Capacity of Resident	Rate (L/c/d)	Demand (L/d)	Demand (L/s)
1	Mawar Hostel	3500	200	700,000	8.1019
2	Melati Hostel	3500	200	700,000	8.1019
Total				1,400,000	16.2038

Total rates of demand for Mawar and Melati hostel, Shah Alam in one day is calculated as below:

Total rate = 16.2038 L/s
= 16.2038 L/s x 24 hrs x 60 min x 60 s
= 1,400,008 L/day
= 1,400.008 m^3/day

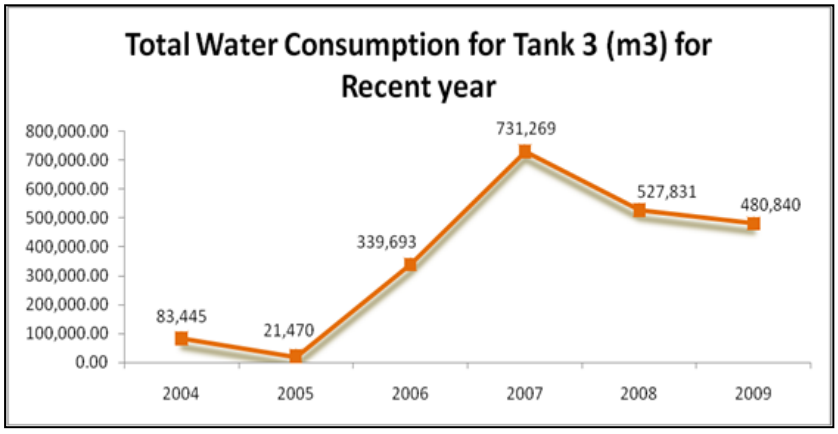

Figure 2. Trend of water consumption supply from water tank 3 to Kolej Mawar and Melati from year of 2004 until 2009.

To check the actual water consumption, analysis was made based on data that was obtained from UiTM Maintenance Unit. Figure 2 below show the trend of water consumption from year 2004 until 2009. The average of water consumption between

those four years was 519,908.25 m^3. This value was taken as an indicator on water demand in Mawar and Melati College. After conversion, the actual water consumption was 1424.41 m^3/d where this amount is larger than rate of water demand calculated using water demand equation. Beside water consumption data, information such as pipe friction, diameter size, length and elevation of all pipes in study area are getting from maintenance unit.

EPANET Simulation

The flowchart of EPANET step is as illustrated in Figure 3.

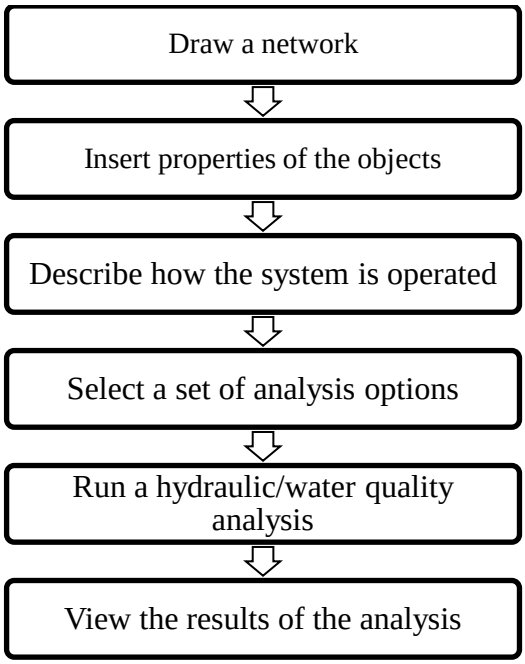

Figure 3. Illustration of step on using EPANET

Time Pattern Setting

Time pattern is used in running an extended period analysis. This is important to make the network more realistic by making demands at the nodes vary in a periodic way over the course of a day. This study is using a pattern time step of 3 hours thus making demands change at eight different times of the day. Beside pattern of time, total duration is also set to be 24 hours which means the network analysis will run for 1-day period of time. In order to create the pattern, multipliers were set for each time period. The multipliers used to modify the demand from its base level in each time period. They are 8 periods within 1-day in this study and the multiplier was set into the software. After having enough information, the network was run and the simulation results were viewed in a few forms. Analysis of this study was done by analysing the value of velocity, pressure and flow at the time of 6am and 6pm.

RESULTS AND DISCUSSION

This study analyse the trend of water pressure, velocity and flow within pipe network using EPANET software. After running the simulation, all locations with high or inadequate pressure, velocity and flow will be obtained. The results were directly viewed on the network map during simulation. The colour of the node and link were changed subjected with time because the values were different with time such as in peak and non-peak hour. In this study, two selected time have been choose which are 6 am and 5 pm. The reason of choosing this two times because of high water used such as bathing and washing. The parameter obtained for each nodes were demand, head, pressure and etc. For the links, the parameters were obtained such as length, diameter, velocity, roughness, flow and etc. However, analysis was focused more on pressure and velocity on the pipe network.

Simulation Result

Network Simulation at 7 am

Figure 4 showed the condition of water distribution at 7 am when pump is opened. Highest pressure at this time was 232.77 kPa which happen at nodes 2 followed by nodes number 12 and 11 with 231.46 kPa and 230.59 kPa, respectively. This high pressure is because of the velocity of water at this time is slightly high due to the high water demand from consumer preparing themselves going to class. In term of velocity, water flow at 7 am shows to be high compared to other time. This can be seen in Figure 4 where overall pipe was coloured with yellow. Besides that, highest velocity was recorded at link pipe 8, 13 and 9 with 3.69 m/s, 2.51 m/s and 2.41 m/s respectively. All this pipes supplies water to water tank above Mawar College building. It has been marked with red colour showing that the velocity was high compared to others. At normal condition higher pressure will cause greater flow through any given pipe size. However, increasing of flow will cause pressure to decrease downstream due to friction loss. This happen because of the water velocity is increasing as well. High quality of water supply system is when capacity of pressure is adequate with type and diameter of the pipes. In this study, most of the pipes have a diameter of 200 mm. In standardized, the actual capacity of pressure in the pipe is 150 to 300 kPA (Ali, 2010). Therefore, the reading given by the EPANET showed that the value is still in the allowable range.

Network simulation at 5 pm

Figure 5 showed the simulation result at 5 pm when pump is opened. Similar with the result obtained at 7 am, during this time water consumption is high due to high water demand. At this hour, it is a time for students or consumer to rest, having a bath, washing and etc. Highest pressure was recorded at node 2 followed by node 11, 12 and 13 with 331.72 kPa, 329.98 kPa, 238.23 kPa and 178.72 kPa, respectively. Other nodes records lower pressure value. However, by comparing with pressure level at 7 am, 5 pm pressure values were much higher and this phenomenon is because total water demand including consumer needs is much concern. Heavy activity such as washing clothes were done during this hour compared in the morning.

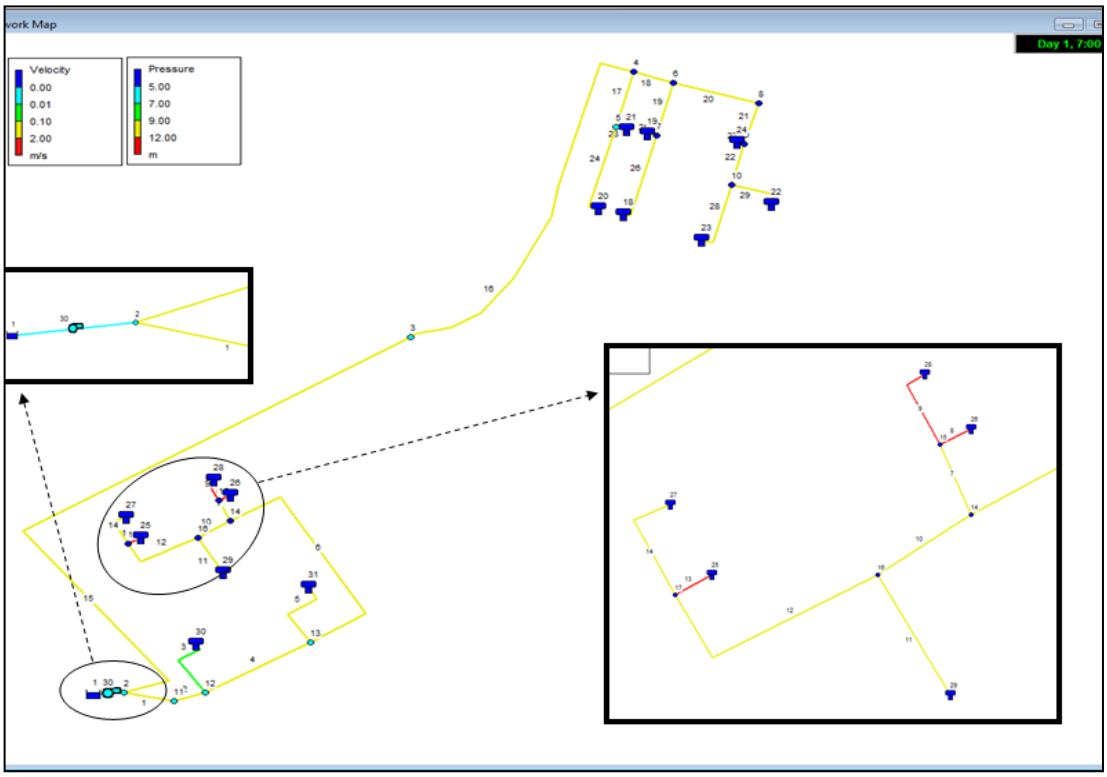

Figure 4. Condition of pipe network at 7am

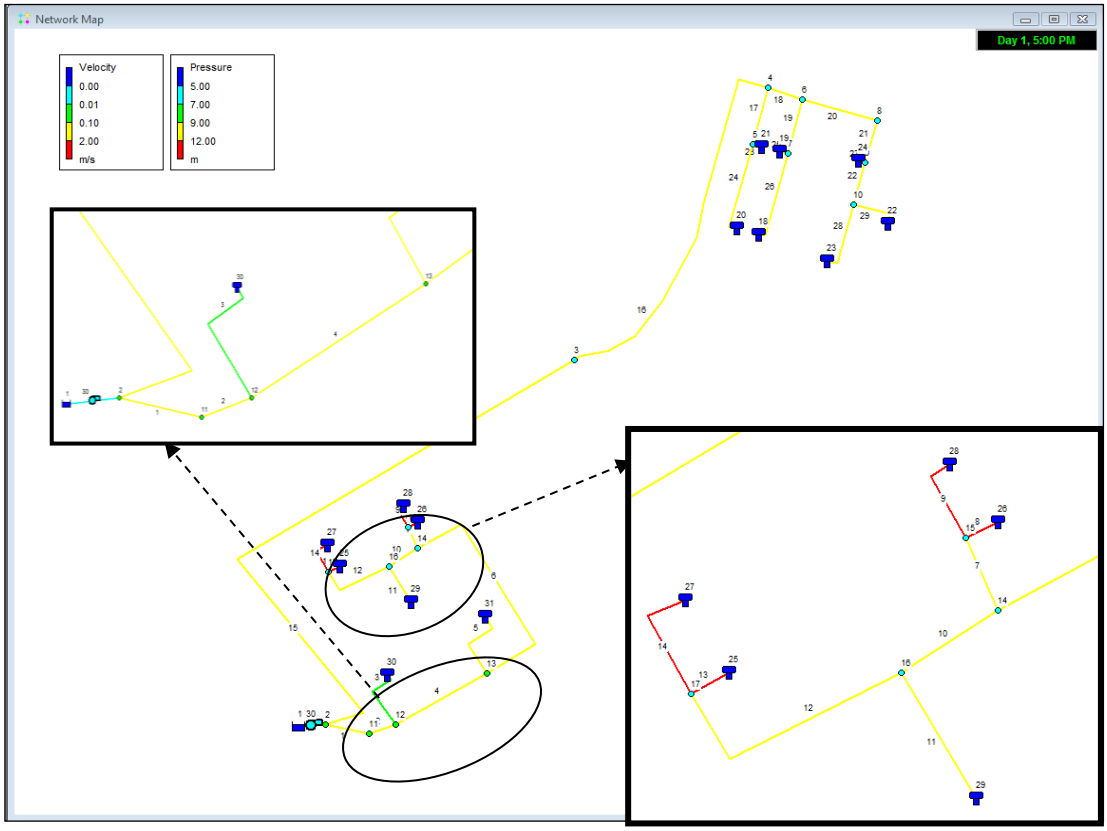

Figure 5. Condition of pipe network at 5pm

Velocity trend is also similar with previous analysis where most of the pipes having velocity in the range of 0.10 m/s to 2 m/s. However, highest value still recorded at Mawar College pipes which labelled as link 8, 13, 9 and 14 with a value of 4.38 m/s, 3.01 m/s, 2.87 m/s and 2.30 m/s, respectively. Besides, location of the node also influenced the pressure value. Nodes 2 located just after the reservoir and pump and was became the first node flowing water into the network. The rest of the nodes does not experience high pressure level and were coloured with blue which means the pressure level exist at lowest pressure range. Both cases gave the same trend velocity. Highest value was also recorded Mawar College. This is because Mawar College has their own pump that contains capacity of 30 m^3/hr at 57 m head which the flow of water distribution can be high and same goes for velocity.

Pressure Distribution

Figure 6 showed the distribution of pressure at 7 am for the whole study area. Highest pressure achieved was 5.34 m or 232.77 kPa. The trend can be seen slightly proportional to the percentage. There are about 32% or 10 nodes from the whole total nodes having pressure less than 4.8 m or 209.23 kPa. Nodes having pressure in the range of 4.8 m (209.23 kPa) to 4.825 m (210.32 kPa) is about 1.9% which equal to only 1 node and the rest of the nodes (19 nodes or 93.3%) were having a pressure between 5.34 m or 232.77 kPa to 4.825 m or 210.32 kPa. Figure 7 shows the distribution of pressure at 5 pm. By comparing with the trend at 7 am, pressure at 5 pm is not directly proportional to the percentage. Most of the nodes were having a pressure between 2 m to 7.61 m or between 87.18 kPa to 331.72 kPa. There is about 62% or 19 nodes from the whole nodes having pressure below than 3.53 m or 153.87 kPa. The rest of the nodes (12 nodes) were having a pressure greater or equal to 6.26 m or 272.87 kPa. From these two patterns of pressure distribution, both trends showed an equal distribution of pressure within the study area at both peak hours.

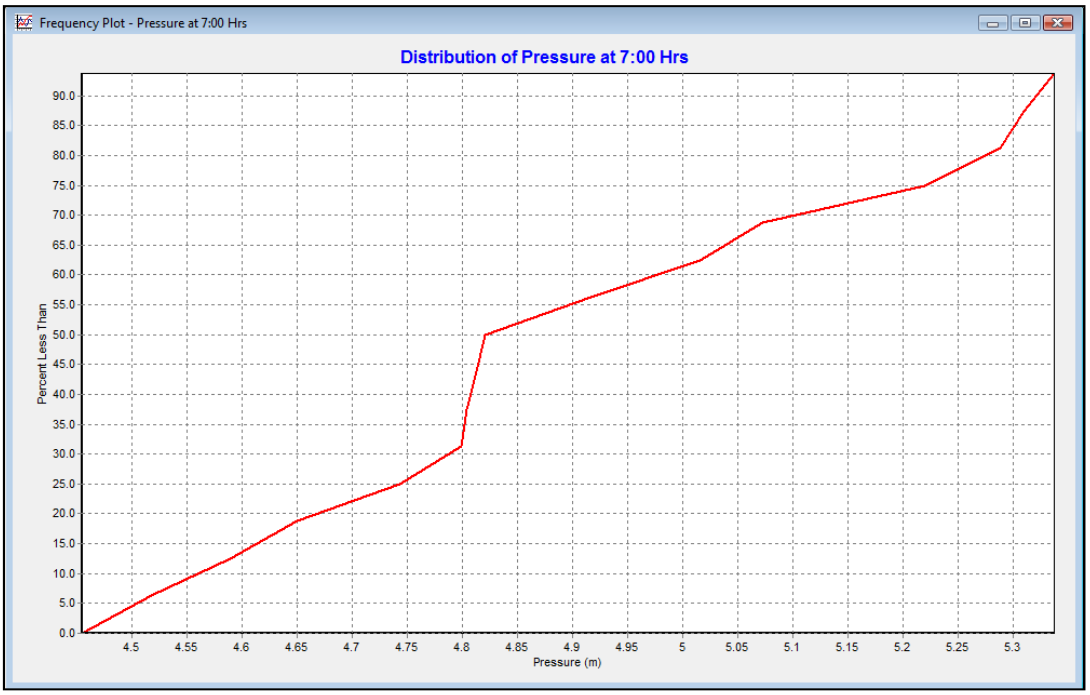

Figure 6. Distribution of pressure at 7 am for the whole area.

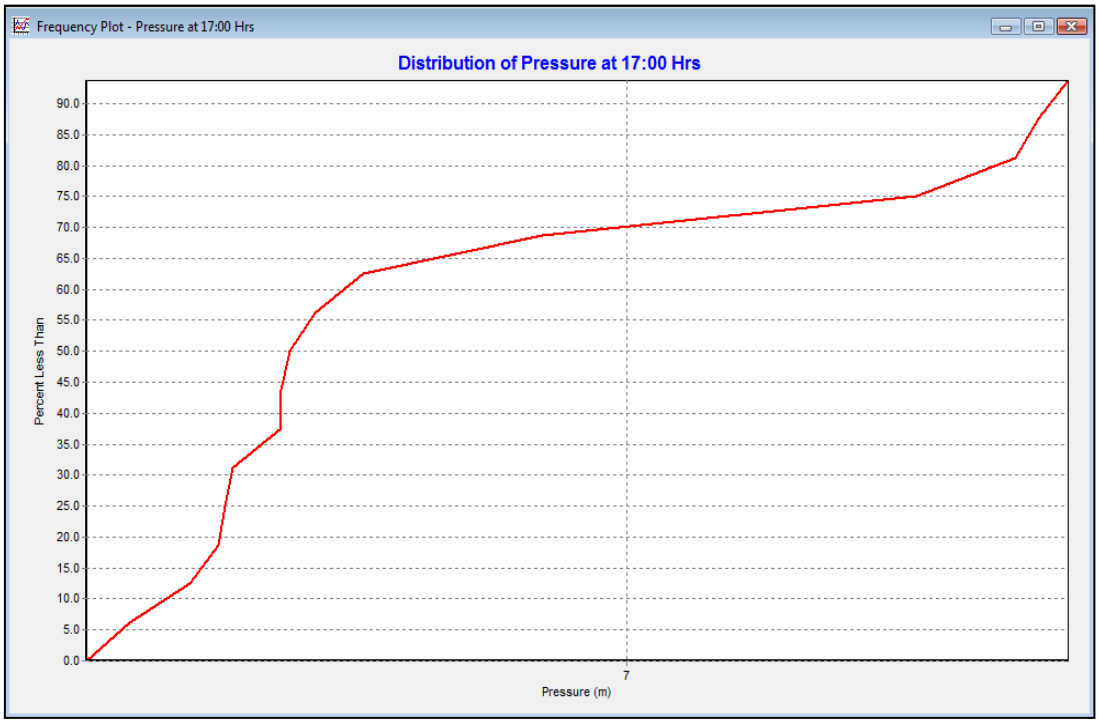

Figure 7. Distribution of pressure at 5 pm for the whole area

Velocity Distribution

Distribution of velocity at 7 am was shown in Figure 8 below. From the graph, about 70% or 21 links including pipes and pump were having a velocity below than 1 m/s. Another 17% or 5 links having a velocity between 1 m/s to 2 m/s. There are about 7.5% or 2 links having a velocity between 2 m/s to 3 m/s and the rest of the links (2 links) were having a velocity greater than 3 m/s but below 4 m/s. For velocity distribution at 5 pm (Figure 9), 73% from the whole system were having a velocity below than 1 m/s. This percentage is equal to 22 out of 30 links. Another 4 links or 12% were having a velocity between 1 m/s to 2 m/s. and the rest of the links which equal to 4 links having a velocity greater than 2 m/s until the maximum velocity in this network which was 4.38 m/s. It can be seen that majority of the pipes having low velocity level. Velocity distribution is important to analyse as it will affect pressure level, minor or major losses and leakage. For this study area, as the velocity is low and the pressure distribution were equally distributed, as discussed on above section, the condition of the pipes is assuming was still in good condition.

Water Loss

For the water loss analysis, this study use water demand as an assumption amount of losses. Comparison between actual and calculation of water demand was made to analyse the differences. Real data was getted from maintenance unit of UiTM Shah Alam. Information from them state that water demand for tank 3 which supplies water to Mawar and Melati hostels is about 519,908.25 m^3/year. Therefore, for one day, the demand was 1424.46 m^3/d. The calculation show the demand in both hostels is 1,400 m^3/d. By comparing this two values, can be seen that it is not a huge different which mean the piping system is stable without any leakage or losses.

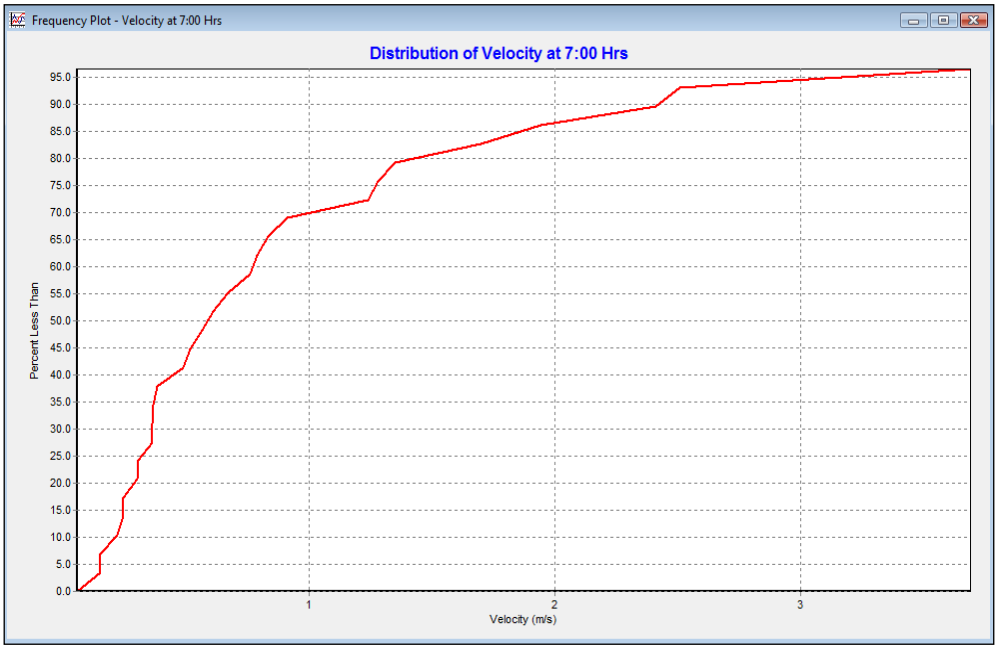

Figure 8. Distribution of velocity at 7 am for the whole area

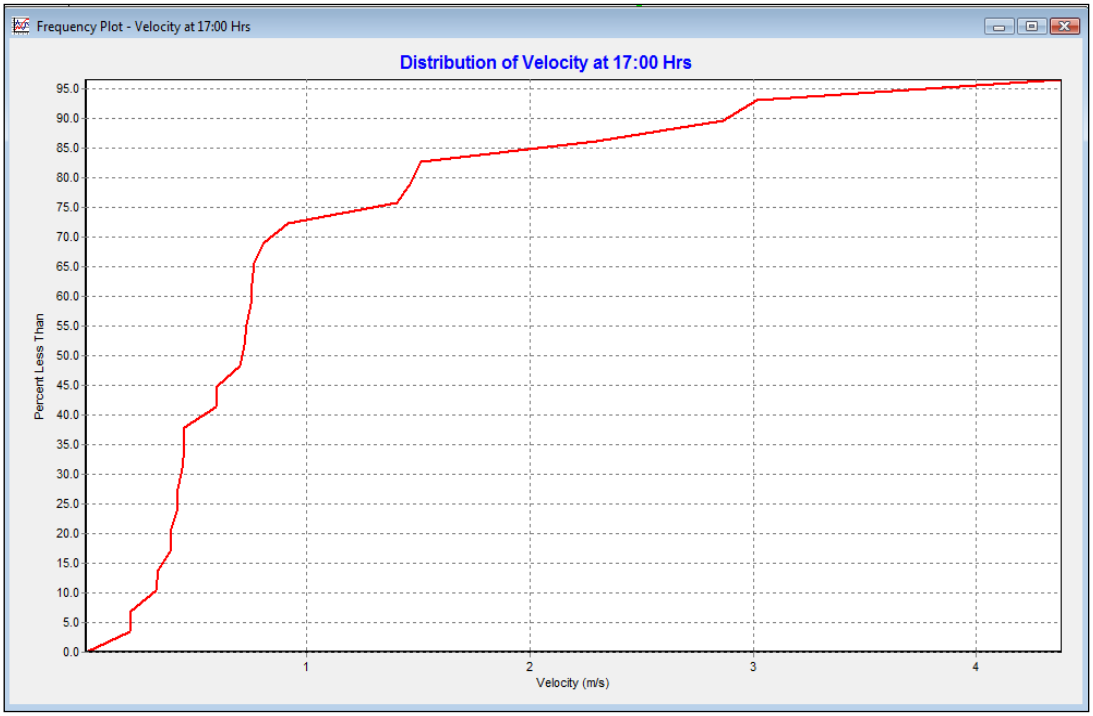

Figure 9. Distribution of velocity at 5 pm for the whole area

CONCLUSION

The current supply infrastructure is still adequate to meet the water needs for both Mawar and Melati Colleges. This is based on the comparison between actual and calculated water demand that has been made. Availability for the infrastructure supplying water is influenced by the proper pressure management. Therefore, high pressure must be controlled efficiently. This study shows Mawar College record highest pressure level for both 7 am and 5 pm with 232.77 kPa and 331.72 kPa, respectively. Both values were recorded at the same nodes labelled as node 2. Most of the pipes are not having too high pressure and still under good condition. This can be seen from comparison of both actual and calculation of water demand. The actual water demand is slightly high compare with calculated amount with different of 24 m^3/d. This differences can be ignored because of the small amount and can be assume that pipe network in the study area is in stable operating system.

RECOMMENDATION

Some recommendations need to be taken in order to produce a better result:

1. In term of pipe materials, some of it have been developing from many years ago especially for old buildings in UITM Shah Alam. When there is new development, pipe overlapping happen. Therefore, current project had use new materials of piping, valve and tank and the problem arise when latest types of materials data cannot be found because there so many piping.
2. High pressure must be controlled effectively. Additional pump should be considered into the system to ensure that the water is distributed with good condition.
3. To reduce potential of water loss, diameter of pipe should be increased in order to reflect with high pressure and high velocity.
4. The other way to control the pressure is control the leakage. "The leakage reduction problem as a whole is complex and requires co-ordinate actions in different areas of water network management, such as direct detection and repair of existing leaks, general pipe rehabilitation programmers, and operational pressure control" (Danielle C.M. *et al.,* 2006). Furthermore, the pressure can control the leakage by installing a valve.

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EFFECT OF ECCENTRICITY ON THE BEHAVIOR OF PULTRUDED FRP BOLTED JOINT

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ABSTRACT

Fibre reinforced polymer (FRP) composites are becoming an alternative choice for the development of structural truss system. It takes advantage of the unidirectional properties of fibre composites as truss members are subjected mostly to axial forces.The typical connection used for this type of structure is a bolted joint. This paper presents the behavior of closed section (100 mm x 75 mm x 5.25 mm) of pultruded glass FRP (GFRP) composite with bolted joint under eccentric loading. The T-joint component of the truss was designed with 1-bottom chord (1B) to simulate the eccentric condition and compared with a T-joint with 2-bottom chords (2B) for concentric loading. Stainless steel bolts (all-threaded) were used and tightened with a torque of 25N.m. The joint failed due to local punching shear at one side of the connection area due to eccentric effect and a load less than half that of the joint with concentric loading. It was found that the testing specimen with eccentricity experienced local damaged which had reduced its joint capability almost twice than that specimen without eccentricity'

Keywords: Pultruded FRP, Bolted Joint, Connection, Eccentricity, Failure modes

INTRODUCTION

Fibre reinforced polymer (FRP) composites materials have excellent attributes for application in civil structures such as buildings, bridges and also for reinforcing and strengthening existing structures. One of the favored FRP manufacturing process in civil construction is pultrusion (Jones and Ellis, 1986). For the past 20 years, pultrusion composites have been acknowledged as an alternative material from conventional and progressively used in the construction industry (Turvey and Wang, 2007). In addition to being a lightweight structure, pultruded glass FRP (GFRP) profiles can offer high resistance to aggressive environment which contributes to lower life cycle cost, high axial resistance and quick installation time (Keller,2001). These inspiring features of pultruded GFRP material are being used for the development of structural truss system and other civil structures as well (Pfeil et al, 2009). Since truss members are subjected only to axial forces, it can take advantage of the unidirectional properties of fibre composites and effectively utilises its material strength (Hizam et al, 2012). One of the main concern arise in designing the structures with pultruded GFRP is to provide an adequate connection system. This area continues to draw attention due to many possibilities of failure modes, the complexity of stress relieving mechanism and the complex nature of the stress fields in the vicinity of the joint (Khashaba, 2006). There are three (3) common techniques used to connect various types of pultruded structures which are bolted joint, adhesively bonded and a combination of both. In terms of

practicality, bolted joint is the most preferable as it is relatively easy to assemble and is capable of transferring high loads (Mottram, 2009). In bolted connection design, the loading directions and fasteners must be arranged in a concentric manner (ASCE, 2010). Most research studies on FRP connection conducted to date are loaded concentrically (Ascione et al, 2010, Vangrimde and Boukhili, 2003, Xiao and Ishikawa, 2005) and there are several studies on the behavior of FRP materials under eccentric loading (Hadi, 2007 and Ragheb, 2010). However in practice, eccentricity may be unavoidable due to practical limitations in fabrication and erection. In addition, discrete load paths employed by bolted connection in order to transfer forces and moments will also influence the behavior of pultruded structure. Thus, studies of pultruded FRP with bolted connection under eccentric loading are important for its practical use. This paper investigates the behavior of pultruded GFRP bolted joints under eccentric loading and compared with the behavior of a double bottom chords (or concentrically loaded joint). All the pultruded GFRP T-joint specimens were tested to failure and its failure behavior were reported.

EXPERIMENTAL PROGRAM

The experimental program of this study involved a total of six (6) pultruded GFRP T-joint specimens had been assembled and were tested to failure in the tensile direction. There were two (2) experimental models prepared which corresponds to the specimens 1B, and 2B. The description of the specimens is listed in Table 1. One bottom chord specimen was used to create eccentric case, while two bottom chords is the typical configuration use in the industry (Figure 2).

Figure 1. Disassembled specimens of pultruded GFRP closed profile.

Table 1. Pultruded GFRP T-joint specimens.

FRP T-Joint group	Description	Nos
1B	1 bottom chord	3
2B	2 bottom chord	3

Material Details and Specimens Preparation

The composite material used for this test is pultruded glass FRP closed profile which was manufactured and supplied by Wagners Composite Fibre Technologies (WCFT). The nominal dimension of the pultruded GFRP closed profile was 100 mm x 75 mm x 5.25 mm. This material consists of reinforcements by long continuous fibres (unidirectional or 0^0) and stitched fabrics ($\pm$ 45^0) which provide high longitudinal strength. The stacking sequence of pultruded glass FRP is 0^0 / 45^0 / 0^0 /-45^0 /0^0 /-45^0 /0^0 /45^0 /0^0. The matrix material is a vinyl ester resin. Table 2 shows the mechanical properties of the pultruded GFRP profile extracted from the WCFT product data sheet.

Table 2. Mechanical properties of 100 mm x 75 mm x 5.25 mm.

Mechanical Properties	Longitudinal	Transverse
Ultimate tensile strength (MPa)	650	41
Ultimate compressive strength (MPa)	550	104
Modulus of Elasticity (MPa)	35400	12900
Shear strength (MPa)	84	
Mass (kg/m)	3.28	
Density (kg/m^3)	1970	

Figure 2 illustrates the geometrical configuration of the pultruded GFRP T-joint and the test fixture used in this experiment. At the connection area between the steel test fixture and test equipment, two (2) M20 stainless bolts and mechanical inserts were used. The mechanical fasteners used to connect the T-joint were stainless steel (SS) 316 M20 (A325) together with SS washers and nuts. A tightening torque of 25 N.m was used to provide clamping pressure as recommended in (Manalo and Mutsuyoshi, 2011). Approximately 22 mm nominal bolt hole diameter was drilled using a special diamond-tipped bit and the edge distance from the bolt hole to base material is approximately 39 mm (2 times bolt diameter).

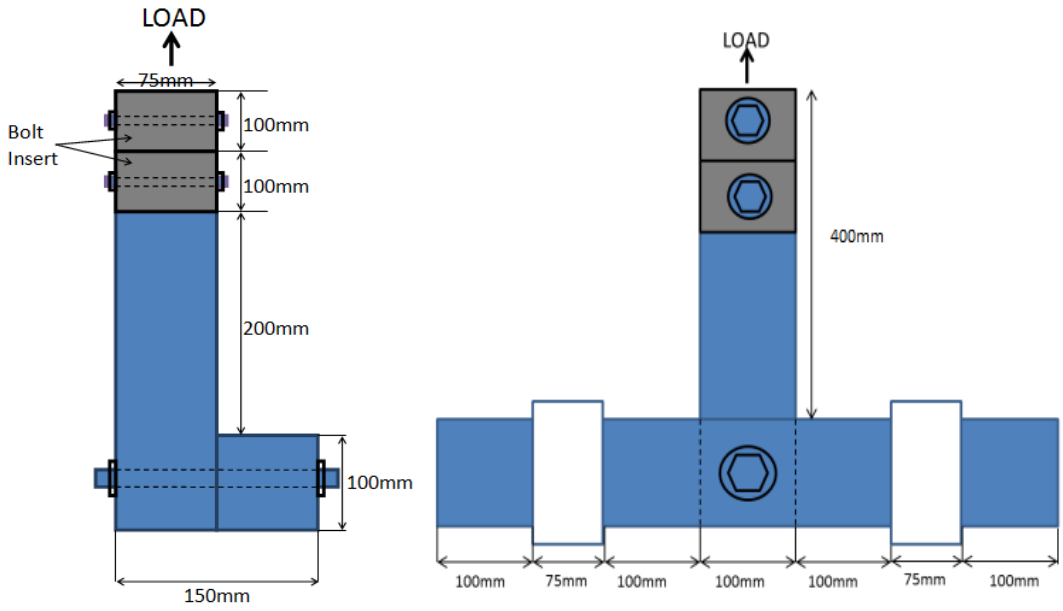

Figure 2. Geometrical configuration of pultrueded GFRP T-joint

Experimental Setup and Instrumentation

Pultruded GFRP T-joint specimens were tested up to failure in a tensile manner at P11 Laboratory of the Faculty of Engineering and Surveying at the University of Southern Queensland. The testing program was conducted using a loading machine (Transducer Techniques, model SWO-50K) with a capacity of 222kN. Steel test fixture was fabricated to attach the specimens at the load cell and the bottom girder of test frame of the machine to restraint the specimen's bottom chord. The experimental set-up is shown in Figure 3. Data logger (system 5000) was used to record the load applied and displacement (using a draw-wire displacement transducer with sensitivity 64.50 mV/V/inch). Calibrations of those instrumentations were performed prior to commencement of testing program. The failure modes of each specimen were observed during the loading and after the test had been completed.

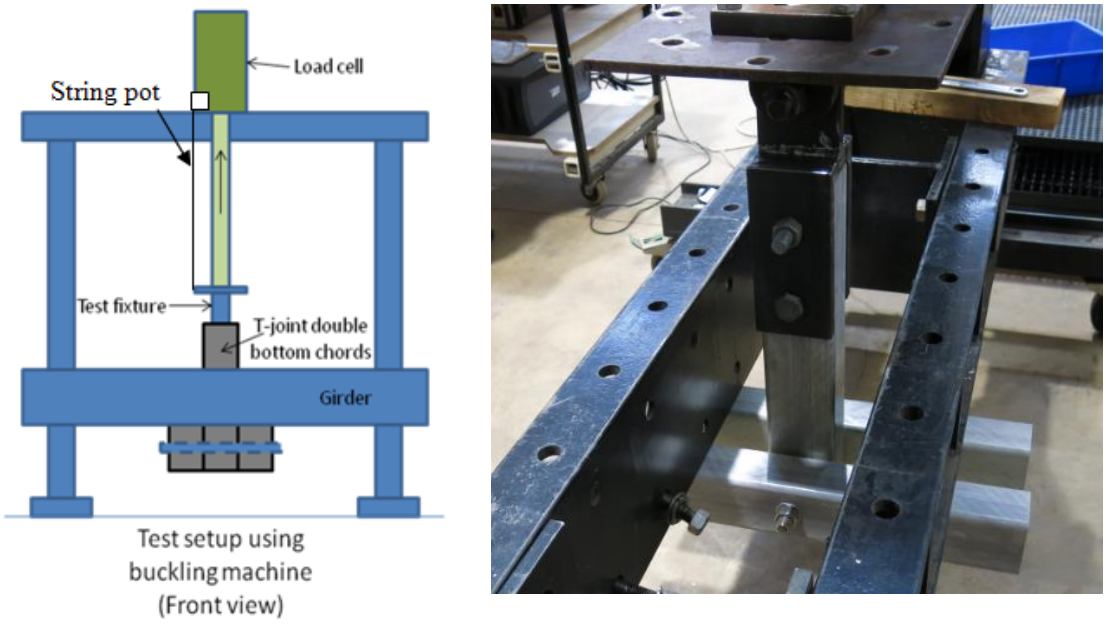

Figure 3. Pultruded GFRP T-joint experimental setup

RESULTS AND DISCUSSION

Table 3 shows the summary of the results of the testing program. Specimen 1B failed at an average load of 14.45 kN with an average displacement of 23.56 mm. Meanwhile, specimen 2B failed at an average load of 37.24 kN with an average displacement of 22.38 mm. It was observed that eccentric condition on pultruded GFRP bolted joint has resulted on reduction of joint strength and influences its failure behavior. The failure behavior of pultruded GFRP bolted joint is presented in the following section.

Effect of eccentric loading

The load and displacement relationship of 1B specimens is presented in Figure 4. All specimens showed almost linear behavior which occurred up to around 10-13kN with displacement between 20-25 mm. After this region, the curve became non-linear until failure. The first cracking sound could be heard at as low as around 8 kN which may indicates that the bolt was starting to slip into bearing. The highest failure load was

obtained by 1B-2 specimen at 15.53 kN. Subsequently, the joint strength slowly decreased and the displacement continued to increase. It was noticed that, after the maximum load, the specimens did not fail abruptly suggesting that the members of T-joint were still intact. This is due to the lateral restrained produced by the bolt axial force (tightening torque). As the load was continued to apply, the contact pressure from the washer had progressively damaging the fibres and had caused local failure.

Table 3. Summary of results.

Specimens	Failure load (N)	Displacement (mm)
1B-1	12,857.81	19.13
1B-2	15,532.61	26.41
1B-3	14,969.50	25.13
Average	14,453.31	23.56
Std dev	1,410.14	3.89
Specimens	**Failure load (N)**	**Displacement (mm)**
2B-1	35,476.30	23.48
2B-2	38,995.78	21.76
2B-3	37,236.04	21.90
Average	37,236.04	22.38
Std dev	1,759.74	0.96

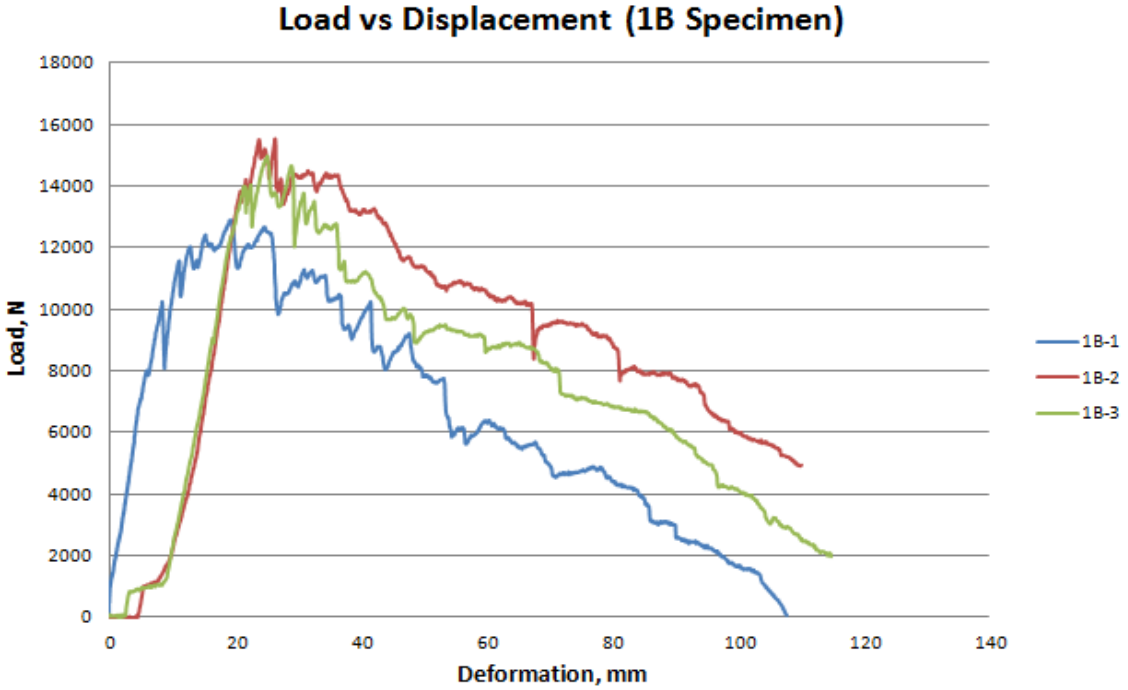

Figure 4. Load-displacement of 1B specimens

In order to further investigate the failure behavior at the connection area, the T-joint components were disassembled. The failure modes of pultruded GFRP T-joint 1B specimens (at connection area) were presented in Figure 5. During the application of the load, the specimens exhibited large rotation at the bottom chord due to moment created. This eventually had caused punching shear on the pultruded GFRP thin-walled which

developed due to the eccentricity of the load applied on the connection. This has significantly affected the joint strength. Providing that the material is relatively low material stiffness and lower strength in the transverse direction (Bai and Yang, 2012), it also prone to fail in that manner. On the opposite plane which is facing the bottom chord, the final failure mode of shear-out was identified. The end distance (approximately 39 mm) to bolt diameter (20 mm) ratio is slightly below the minimum recommended parameters (which is 2) for lap joint connections (Bank, 2006). Since the material possesses low in-plane shear strength and together with the small edge distance in the direction of the load applied, it triggered the shear-out failure to occur. No sign of failure in the bolt was seen for the 1B specimens.

Figure 5. Failure modes of 1B specimens

Figure 6 shows the load-displacement behavior of 2B specimens. At an applied load of approximately 5 kN, the graph showed linear behavior up to final failure. At this stage, the load was transferred to the stainless steel threaded bolt, progressively damaging and shearing the thin wall of the pultruded GFRP. The average maximum load obtained for 2B specimen was 37.24 kN with a displacement of 22.38 mm. At the peak of the graph, there were several knees (in non-linear fashion) which may indicate some internal damage had occurred as the joint capacity decreased. After maximum load, the specimens were still capable to carry some loads, even though at a decreasing capacity, possibly due to the lateral restrained from both bottom chords which were obtained from the tightening torque of the bolt. After the loading was released, the specimens were disassembled and close visual inspections were made at the connection area to identify mode of failure. Figure 7 shows the failure modes of 2B specimens. All the 2B specimens failed in the same manner. The specimens failed due to shear-out at both sides and marginal bearing (local crushing) was observed at the bottom chord members. In the 2B specimens, the load applied were evenly distributed at both sides of connected area and developed identical failure mode. It was also observed that, the pultruded material in direct contact with the threaded bolt was heavily crushed and delaminated. With the thread, a significant reduction of joint strength identified when compare to the plain pin joint strength (Matharu and Mottram, 2012).

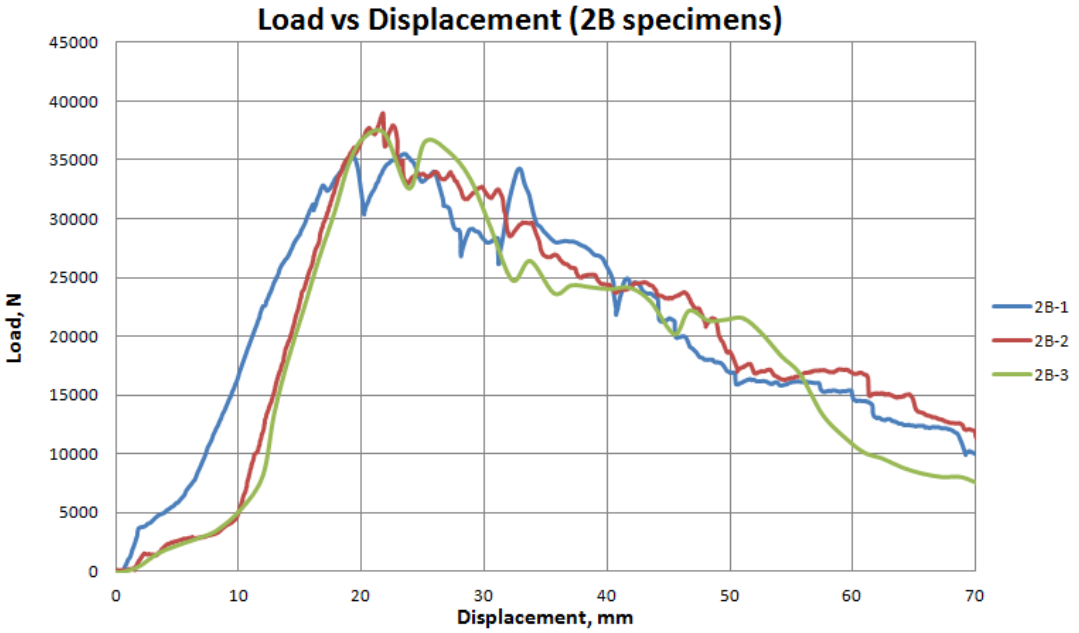

Figure 6. Load and displacement behavior for 2 bottom chord specimens

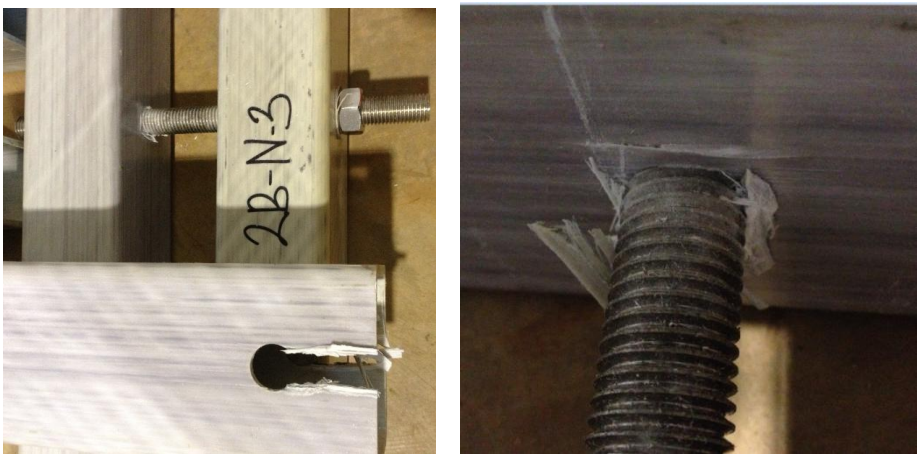

Figure 7. Failure modes of 2B specimens

Figure 8 shows the comparison of load-displacement behavior between 2B specimen and 1B specimen. According to the experimental results, the 2B specimen recorded more than twice the strength of bolted joint of 1B specimen. Contribution of two bottom chords have created concentric loading path, while eccentricity on 1B specimen significantly reduced the bolted joint capacity. The shear-out failure was observed on both 1B and 2B specimens. It developed predominantly due to combination of low end distance to bolt diameter ratio and low in-plane shear strength of the material. Local punching shear was observed at 1B specimen due to the moment created by eccentric loading. This could be improved if the rotational at the connection area due to eccentricity could be restrained. Closed profile (rectangular shapes) of pultruded GFPR was chosen because it can improve the torsional rigidity, stiffness and the weak axis strength (Smith et al, 1998), however in this study, the eccentricity spacing is too big to endure. By introducing some type of filler inside the hollow section especially at the

connection area, it might help to improve the joint strength, rigidity and restrict rotational movement.

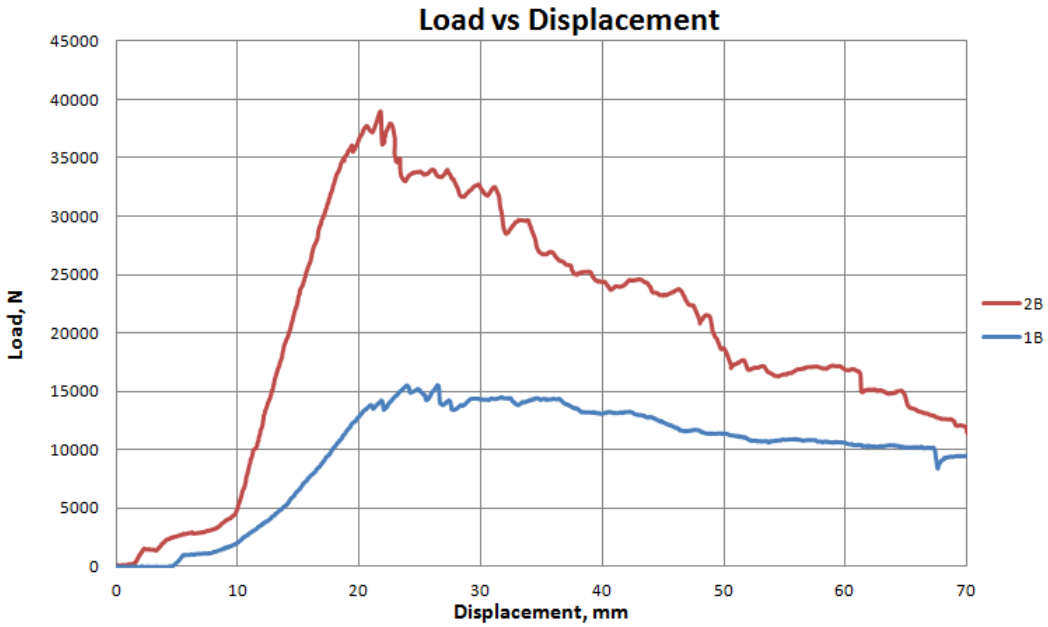

Figure 8. Load-displacement relationship between 2B and 1B specimen

CONCLUSION

Six specimens of pultruded GFRP bolted joint had been tested in two cases, with and without eccentricity. The results showed that the joint strength is significantly decreased due to the effect of eccentric loading. For 1B specimens, different mode of failure from the typical FRP connection failure modes was observed. The local punching shear was developed at one side of the connection area due to eccentric effect and resulted in reducing bolted joint strength.

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